AFIT/GCA/LSY/92S-1

THE EFFECTS OF ICONIC PRESENTATION ON INDIVIDUALS

THESIS

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THESIS

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Preface

The purpose of this research was to compare the impression of an iconic graph to the impression of a traditional graph based on the same data to determine if there is a difference.

An experiment was conducted at the Air Force Institute of Technology (AFIT) using pictures of traditional bar charts and iconic charts contained in a notebook. The control group received traditional bar charts and the experimental group received iconic charts made with the same data. By measuring the impressions created by the graphs it was determined that the method of presentation did not affect an individual's interpretation of a graph. The subjects did, however, express a preference for the traditional graphs over the iconic graphs. It was also determined that gender did not have an affect on an individual's ability to interpret a graph.

We wish to thank the many classmates who assisted in the two pretests, the AFIT faculty who allowed us to use their students as subjects, and the subjects themselves.

Our thesis committee, Major David Christensen and Major Robert Pappas, also provided invaluable guidance in the preparation and administration of the experiment, as well as this publication.

Finally, we would like to thank our families and friends for their support during our time at AFIT.

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Abstract

This thesis investigated whether individuals interpreted iconic graphs differently than traditional graphs. A literature review revealed a lack of current research concerning iconic graphs. Using guidelines previously created for high-integrity graphics, a timed, pretest-posttest experiment was developed to compare the impressions rendered by both traditional and iconic graphs and to determine whether men and women interpret the two types of graphs in the same way. It was also used to determine whether traditional bar graphs or iconic graphs were preferred by the subjects. Ninety-nine subjects, all employees of the Royal Australian Air Force, United States Air force, or defense contractors, were involved in the experiment. Through the use of the Mann-Whitney U test, it was determined that the method of presentation did not affect an individual's interpretation of the graph. Individuals did, however, prefer the traditional methods of presentation over the iconic methods of presentation. It was also determined that gender did not have an affect on an individual's ability to interpret a graph.

THE EFFECTS OF ICONIC PRESENTATION ON INDIVIDUALS

I. Introduction

General Purpose

Previous research has indicated that the method of graphics presentation can affect a person's ability to interpret data (Cleveland and McGill, 1985; Cochran, Albrecht, and Green, 1989; Kern, 1991; Larkin, 1990; MacKay and Villarreal, 1987). Previous theses done at the Air Force Institute of Technology (AFIT) in the area of graphics have focused on traditional graphics methods such as line and bar graphs (Kern, 1991 and Larkin, 1990).

There are currently over 100 software packages available for developing charts and graphs. The National Computer Graphics Association estimates the business graphics software market will reach $26 billion by 1993, of which half is for presentation graphics products (Caron, 1991:93). This growth of business graphics software is a result of heightened interest in advanced graphics, more powerful and affordable computer hardware, and easier graphics software. Because of the need for businesses to quickly disseminate large volumes of information, computer graphics has become a vital tool (Caron, 1991:93). Additionally, businesses rely on sophisticated graphics software to communicate ideas, disseminate information, and improve their corporate image (Barker and others, 1992:226). The proliferation of computers in the workplace and software packages containing graphics capabilities has made it easier to make graphs. More of these software packages include a compendium of icons that can be used in conjunction with or in lieu of traditional graphics. For the purposes of this thesis, an icon will be defined as a pictorial image used to depict data. These icons can be used to create sophisticated iconic graphs (also known as pictographs) without a skilled graphics artist. As a result, we foresee an increased use of iconic graphs in data presentation. The threefold increase in sales of graphics presentation packages supports this (Miller, 1992:114). Although sales and usage of these packages has increased, there has been little to no attention paid to proper usage of iconic graphs.

Specific Problem

The purpose of this research is to compare the impression of an iconic graph to the impression of a traditional graph to determine if there is a difference.

Three methods of iconic graphic presentation were used to depict data: vertical iconic, horizontal iconic, and iconic area manipulation. Vertical iconic graphs (Figure 1) use stacked icons to reach the desired point on the Y axis. The icon is consistent in size, shape, and color. Horizontal iconic graphs (Figure 2) line the icons side by

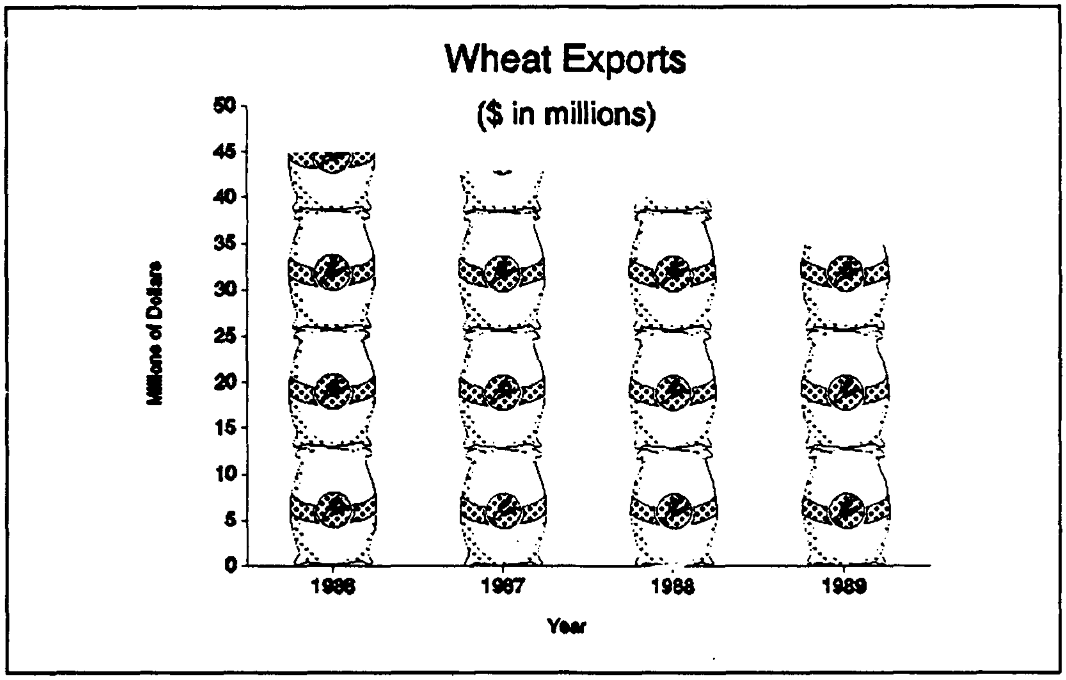


Figure 1. Vertical Iconic Graph

side from the Y axis to the desired point on the X axis. These icons are also consistent in size, shape, and color. The third form of iconic graphic presentation uses only one icon to represent each data point. The size of the icon is manipulated to make the icon big enough to reach the desired point on the Y axis which also affects the width (Figure 3). Other forms of graphics presentation, such as background icons, will not be studied here.

For the purposes of this study, traditional graphs will be limited to horizontal and vertical bar graphs (Figure 4). We felt that the use of bar graphs best represents, in area, the iconic graphs, thus providing the most reliable means of comparison. Previous research has shown that, by changing the graphic method, the perception of the data presented by

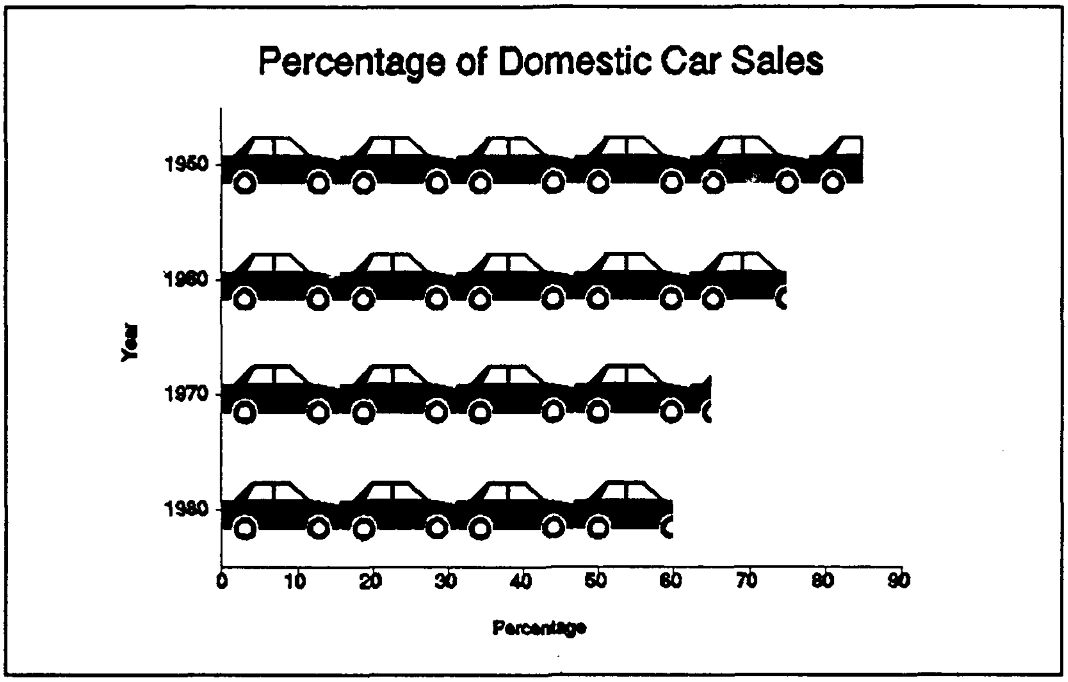


Figure 2. Horizontal Iconic Graph

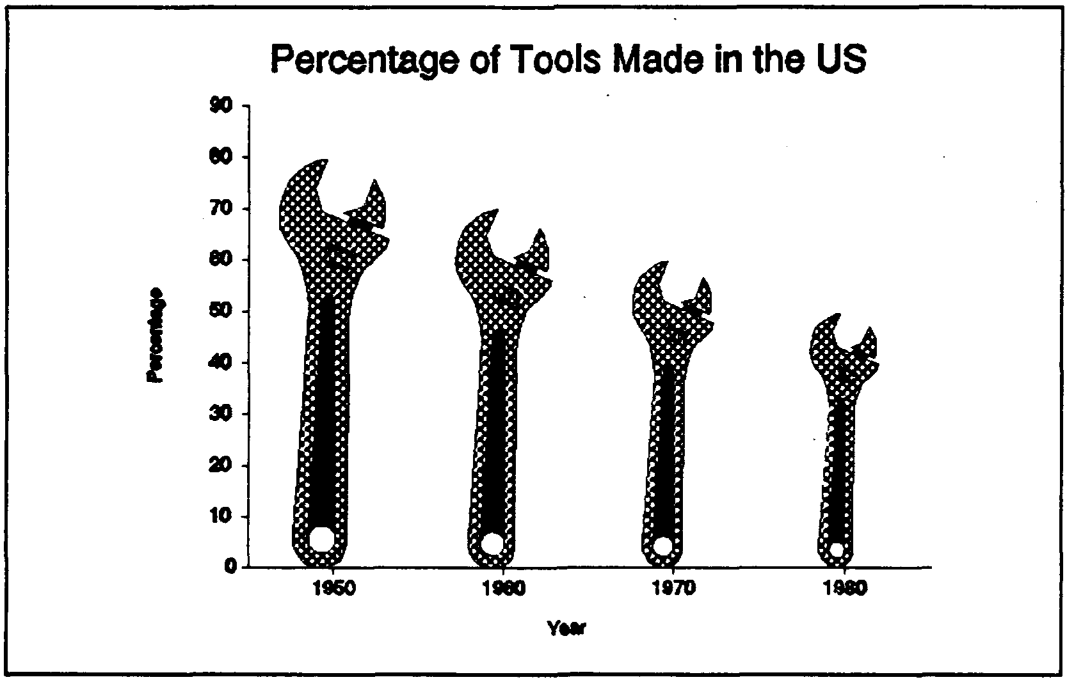


Figure 3. Iconic Area Manipulation Graph

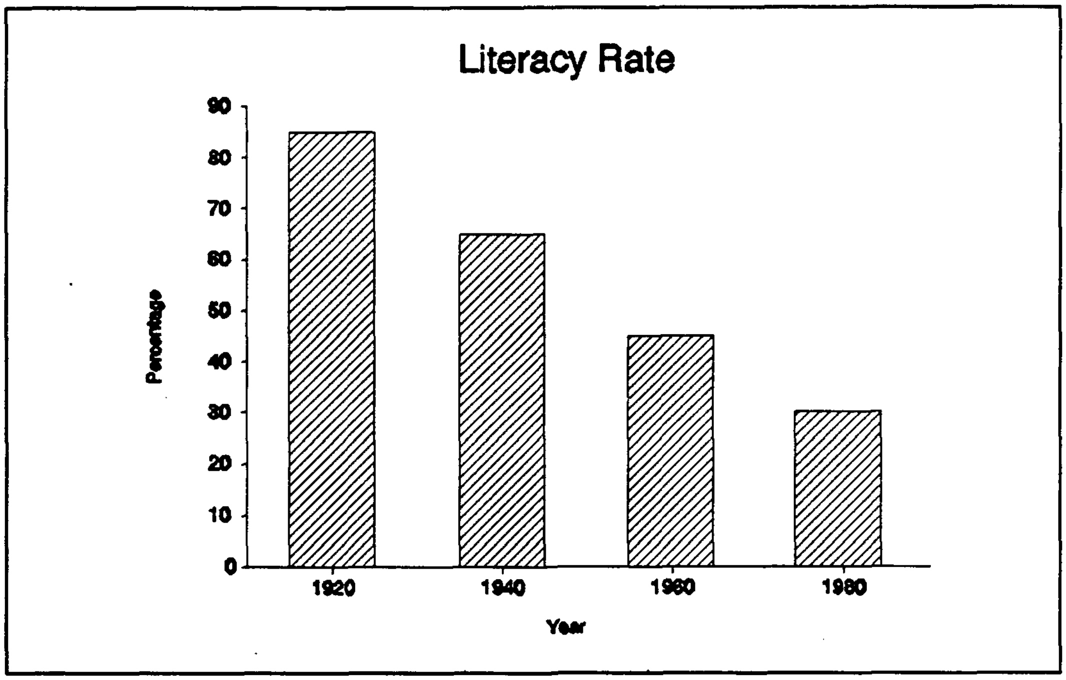


Figure 4. Traditional Bar Graph

the graph is changed (Cleveland and McGill, 1985; Cochran, Albrecht, and Green, 1989; Kern, 1991; Larkin, 1990; MacKay and Villarreal, 1987). This will be discussed in greater detail in Chapter II.

To limit the variability in this study, other graphics variables such as color, data distortion, and subject relevancy were eliminated. Icons that might induce strong emotional reactions were not used in the experimental charts, but they were included in the masked charts to determine if it would alter the subjects' impression of a trend. The experimental charts were the charts used to analyze the difference between the use interpretation of iconic graphs and traditional bar graphs. The masked charts were used to hide the specific intent of the experiment.

These charts were also iconic charts. All graphs will be presented in black and white to eliminate the bias of color (Hoadley, 1990:121). The data in this study will not be deliberately distorted nor will its presentation violate accepted graphics presentation rules (Larkin, 1990:21-2; Modley and Lowenstein, 1952:47). These accepted graphics rules are listed in Chapter II.

The icons used will be relevant to the subject area. For example, savings will be represented by bags of money. By using common symbols that represent the subject area, the effect that the icon itself has on the presentation method was reduced. In addition, subject areas were selected that were considered noncontroversial to reduce the emotional biases that may be evoked by an icon. For example, a nuclear cloud might provoke such a strong emotional reaction that the trend impression would be secondary to the icon impression.

<u>Hypotheses</u>

Since icons can be used in different ways, three presentation methods were explored. There will also be an examination of possible gender bias in this study. The examination of gender bias is based on a study by MacKay and Villarreal which discovered that female subjects were better able to interpret multivariate graphs than their male counterparts (MacKay and Villarreal, 1987:544). The following hypotheses will be investigated:

1a. Iconic graphic area manipulation will not affect a person's impression of a graph.

1b. Subjects have no preference between iconic graphic area manipulation and traditional graphs.

2a. Horizontal iconic graphs will not affect a person's impression of a graph.

2b. Subjects have no preference difference between horizontal iconic graphs and traditional graphs.

3a. Vertical iconic graphs will not affect a person's impression of a graph.

3b. Subjects have no preference difference between vertical iconic graphs and traditional graphs.

4. Gender will not affect the impression of the iconic graphs.

The remainder of this thesis will demonstrate the reasoning behind the selection of these hypotheses, their testing, and the analysis of the results.

Synopsis

Chapter II, the literature review, will summarize the research and studies performed on graphics that are pertinent to this thesis. Chapter III, Methodology, will explain the research design, methods of icon selection, population sample, experiment development and management, and statistical tests used. There will also be an example of how the statistical tests were used. Chapter IV, Findings and Analysis, will include comments on the administration of the experiment, the results of the experiment, and the meaning of these results. Chapter V will discuss which hypotheses were accepted and rejected.

Given these results, recommendations for future areas of research will be addressed.

II. Literature Review

The purpose of this literature review is to consolidate information gleaned from previous research and publications. This chapter will include the findings and opinions of previous research pertinent to the conceptual efforts required for the construction and administration of the experiment and its design.

This chapter is divided into six sections: managerial implications of graphics, graphics standards, icons, human factor considerations and psychological theory, other graphical considerations, and future problems. The first section discusses the implications of computer graphics to decision-makers and managers. The second section reviews the evolution of graphics and the current graphical standards. It also addresses purposes for the various methods of graphical presentation. The third section will demonstrate the evolution of and types of icons used to represent data. Also discussed will be icon selection, the ink factor, and the lie factor. Section four contains a review of the literature concerning human factors and the psychological theories pertaining to the use of graphics. Section five contains graphical tools not used in this experiment and why they were excluded. The final section reviews problems in the use of iconic graphs.

Managerial Implications of Computer Graphics

Managers have come to rely on Management Information Systems and Decision Support Systems and their graphic capabilities to get a quick status of their organizations (Evans, 1984:36). The three main uses of graphics in business are computer aided design, production of graphical images, and management graphics. Computer aided design is used in engineering and architecture. Production of graphic images includes filmmaking, publishing, and advertizing products. Management graphics is used for two types of tasks, communication and decision support.

The communication task includes the development of presentation charts. Studies have shown that the use of visual aids can make a presentation more persuasive and can improve the audience's perception of the presenter (Barker and others, 1992:226; Miller, 1992:113; and Sopko, 1991:56). Ms Virginia Johnson, manager of the Meeting Management Institute, a research clearing house founded by 3M Company has found that by using visual aids retention is doubled to about 50 percent. If listeners are really interested the figure may rise to 90 percent. Ms Johnson also found that speech and graphics support each other in the improved retention. It was not stated whether these figures were the result of an empirical study or an experiment. (Sopko, 1991:54)

The decision support task uses computer resources as an aid in problem solving (Lehman, 1986:24-25). The decision support capabilities currently available in graphics software offer businesses a wide variety of tools to better manage their operations. These capabilities include ". . .forms generation, inventory and production monitoring, product planning, PERT chart scheduling, training programs, econometric modeling, financial status monitoring and planning, portfolio analysis, marketing analysis, strategic planning, sales analysis and forecasts, and both plant and project management" (Evans, 1984:36).

Recognizing the importance of graphics to today's manager, software companies now offer advanced features in their graphics packages to include:

1. The ability to rotate, expand, or shrink images
2. The ability to use images created with other software packages
3. The ability to use clip-art images
4. The ability to import scanned images (Caron, 1991:93)

<u>Graphics Standards</u>

Today's products and services must comply with certain industry and consumer standards. These standards insure safety and a reliable product. In order for the average individual to interpret a graph in a textbook, newspaper, or annual report, they need to rely on the creators of the graphs to present the information correctly. In the past, there were few graphics artists, so consistency was not a problem. However, due to the proliferation of software packages containing graphics capabilities, it no longer takes an expert technician to produce computerized graphics. Because of these increased graphics capabilities, the use of graphics presentation in financial statements has become commonplace.

Unfortunately, most people do not know how to properly construct graphs (Lehman and others, 1984:121-2). The use of graphs in financial reporting has prompted many studies on the validity of these graphs (Johnson, Rice, and Roemmich, 1980; Steinbart, 1989; Taylor and Anderson, 1986). Johnson, Rice, and Roemmich (1980:52) found that 42 percent of the annual reports analyzed contained improperly constructed graphs. In the Steinbart study, 26 percent of the graphs from 120 annual reports were improperly constructed (Steinbart, 1989:65). A survey of annual reports from the Fortune 500 companies performed by the Illinois CPA Society in 1987 found that only one third of the reports did not contain graphs. The others used some form of graph. These reports contained an average of 7.9 financial graphs and 4.5 non-financial graphs. The reports were from 1985 and 1986 (Babad and Jarett, 1987:8).

The evolution of graphics standards had its start in 1915 with the Joint Committee on Standards for Graphic Representation (Larkin, 1990:18). Since then, other individuals and groups have improved and added to the original standards for formatting and presenting graphs (Christensen and Larkin, 1992:130-131).

Larkin consolidated previous guidelines to recommend twelve criteria for creating high-integrity graphics. Larkin defines these graphs as well made graphs that will not mislead the reader.

1. Axes should begin at the zero baseline.
2. Multiple scales should be avoided.
3. The dependent axis should employ a simple arithmetic scale.
4. The scale should not extend much beyond the highest or lowest points on the graph.
5. The same unit scale should be used when multiple curves are shown.
6. Label the axes to prevent ambiguity and graphical distortion.
7. Quantities should be labeled in linear magnitudes and not area or volume.
8. For area graphs, the more irregular strata should be placed near the top.
9. Scale divisions must be equal.
10. Keep charts simple for clarity.
11. The horizontal scale should be read from left to right, and the vertical scale from bottom to top.
12. The general arrangement of the graph should be from left to right. (Larkin, 1990:21-2)

Unfortunately, many graphics software packages do not abide by these guidelines, so it is up to the user to manually change the default parameters to match the guidelines. For example, in the creation of the graphs used in this study, we had to manually set the dependent axis to zero and set the interval length for each axis.

There are also guidelines regarding the types of traditional graphic display. The best type of graph depends on the amount and type of information presented. In their article, Cochran, Albrecht, and Green recommend the use of tables if there is very little data (Cochran, Albrecht, and Green, 1989:25). MacGregor and Lehman have also studied graphical presentation methods. They all agree that when trends, series of data, or frequency distributions are shown, line graphs should be used. Bar graphs and column graphs compare data by changing the length of a bar. These graphs can show changes in one item over a period of time and differences in several items at a point in time. Different colored or shaded bars can represent two or more elements at the same time. There is also a 100 percent column chart that shows the relationship of component parts of a whole. Pie graphs are also used to show the relative distribution among a group of data (Cochran, Albrecht, and Green, 1989:26-7; Lehman, 1986:26-28; and MacGregor, 1978:106-107).

Another recommendation by Cochran, Albrecht, and Green (1989:28) is to reduce clutter and uninformative detail. Their research was based on previous studies. One of these earlier studies was by Tufte, who felt that "that extraneous lines and shading be removed" (Tufte, 1983:183). The amount of ink used to print the real data is divided by the total amount of ink used in the graph resulting in an ink factor or data-ink ratio: the higher the ratio, the clearer the message (Cochran, Albrecht, and Green, 1989:28; Tufte, 1983:93).

In the experiment designed for this thesis, all the above standards and recommendations are met save two. In the traditional graphs, trend data will be represented by bar graphs instead of lines. Bar graphs best represent, in size and area, iconic presentation methods. In the book Pictographs and Graphs: How to Make and Use Them by Modley and Lowenstein, bar graphs are the only method of comparison to the iconic displays. This is an attempt to keep the ink factor or ratio constant and provide enough of a basis to relax the convention of using a line graph to represent trend data.

The other criterion for graphical display not being used in this study is that of the vertical scale going from bottom to top. On the horizontal bar and iconic graphs, the scale (always in years) will be from top to bottom. Because years need not start at a zero base and because this type of data is normally presented in the fashion used in this experiment, the spirit of the criterion is met. It is also correctly sequenced for reading style. Americans read from left to right, top to bottom, and since the data on the vertical axis is traditionally shown on the horizontal axis, the data will be presented in the same order as in vertical graphs.

Icons

While icons have been used to represent data and ideas for 37,000 years, Willard Brinton's Graphic Methods of 1914 contains the first pictographs published in this country. In the 1920s and 1930s, there was an attempt by Dr. Otto Neurath of Vienna to create a pictograph system with its own rules (a symbol dictionary) that could form an international picture language. While his system was not universally accepted, his symbols are still in use throughout Europe (Modley and Lowenstein, 1952:4-9).

Dr. Neurath also sparked American interest in graphics. For example, President Franklin Roosevelt's New Deal agencies used graphics to tell their story and gain support. Schools, corporations, and advertising also quickly jumped onto the graphic bandwagon. In America, however, there has been resistance to standardize symbols. It was felt that standardization would prevent adaptations to new audiences (Modley and Lowenstein, 1952:8).

Modley and Lowenstein felt there should be basic guidelines for choosing pictograph/graphic symbols. The first is that pictorial symbols should be self-explanatory. A symbol of a band-aid might represent band-aid sales or use of band-aids in hospitals, but not car accidents (Figures 5a and 5b).

Second, changes in numbers should be shown by more or fewer symbols, not by larger or smaller symbols. Changing

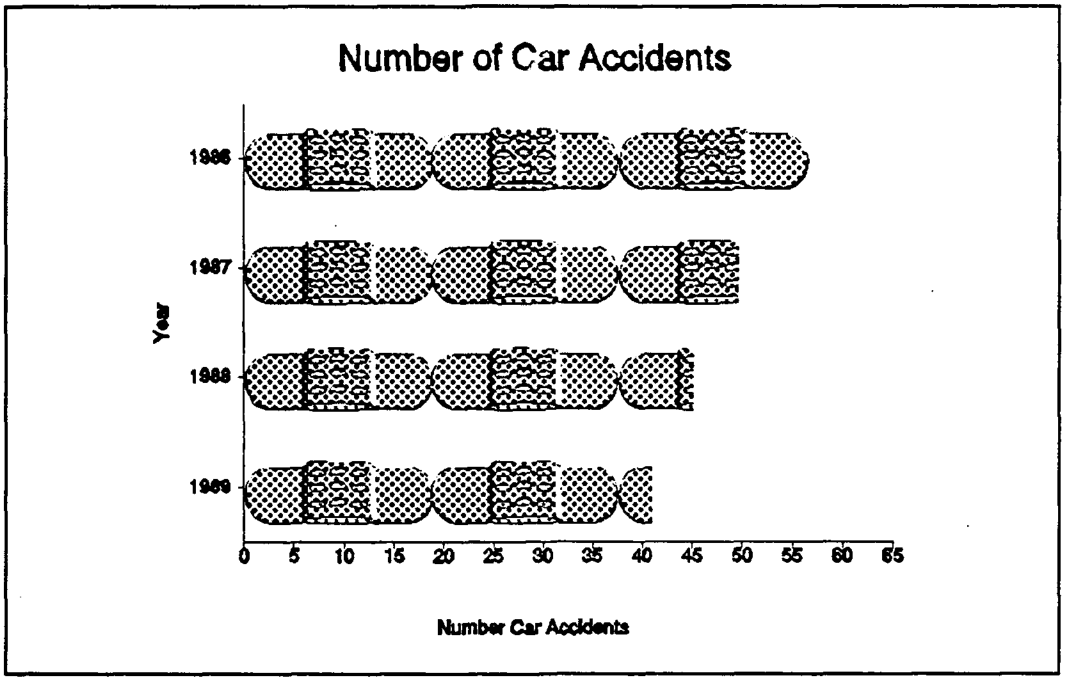


Figure 5a. Ambiguous Symbol

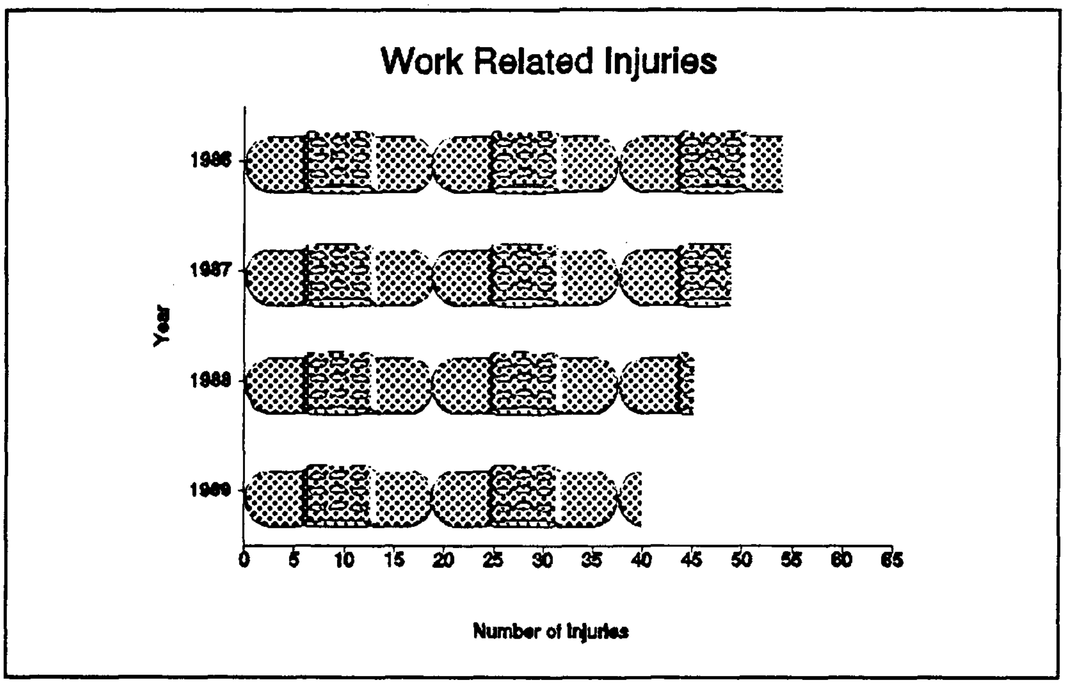


Figure 5b. Self Explanatory Symbol

the size of the symbol may be interpreted as an increase in the size of an item instead of an increase in the amount of an item. An example from our experiment is the use of the bomb icon. Are bombs getting smaller or are there fewer bombs? Obviously, by changing the size of an icon, the area is also changed, which may unreasonably alter the viewers' perspective of the data. Size manipulation (Figure 6a) was tested in hypothesis 1a. The use of multiple icons (Figure 6b) was tested in hypotheses 2a and 3a.

The third guideline is to include the actual figures in the graph. Pictographs give an overall picture, but do not give the minute details. Because one symbol may represent millions of units, a subtle change is difficult to notice (Figures 7a and 7b). This guideline was not tested in this experiment.

The fourth guideline is to use pictographs for comparisons, not flat statements. One house on a pictograph means nothing, but several data points showing various quantities of houses show a trend (Figures 8a and 8b).

Finally, the graphs must be simple and convey only the essential facts (Figures 9a and 9b). For example, an icon that contains too much detail may obscure the essential purpose of the graph. (Modley and Lowenstein, 1952:24-27).

Icons and pictures transcend language barriers, but in order to communicate the correct information, the right icon must be used. Icons can be used to consolidate large amounts of information, but they can also cause "cognitive

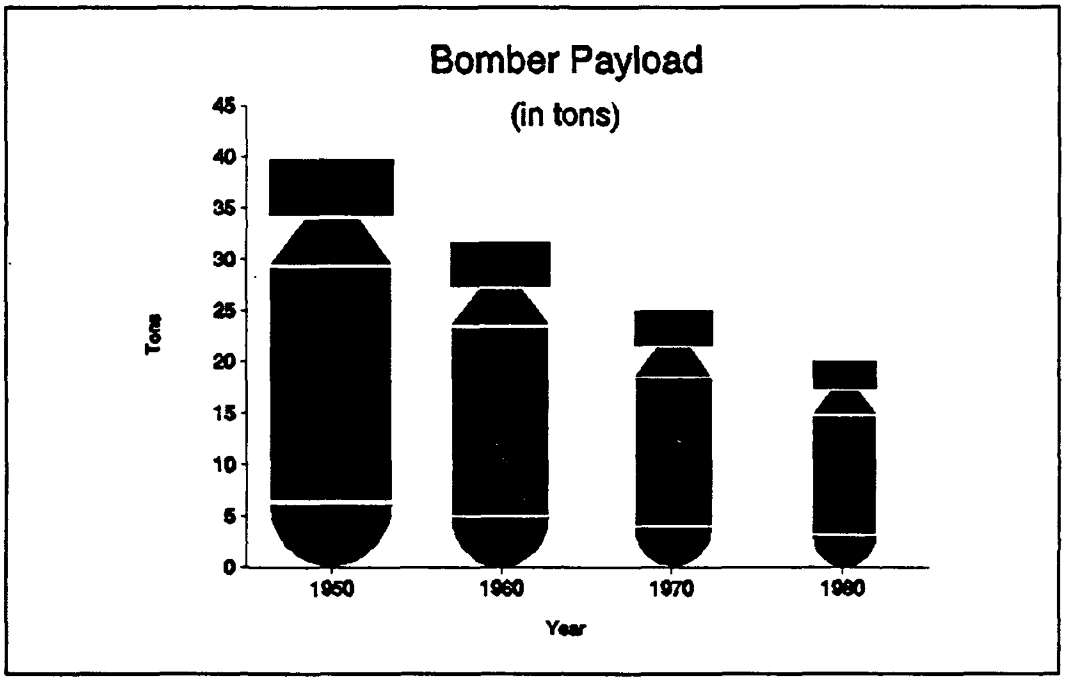


Figure 6a. Size Change to Represent Value Changes

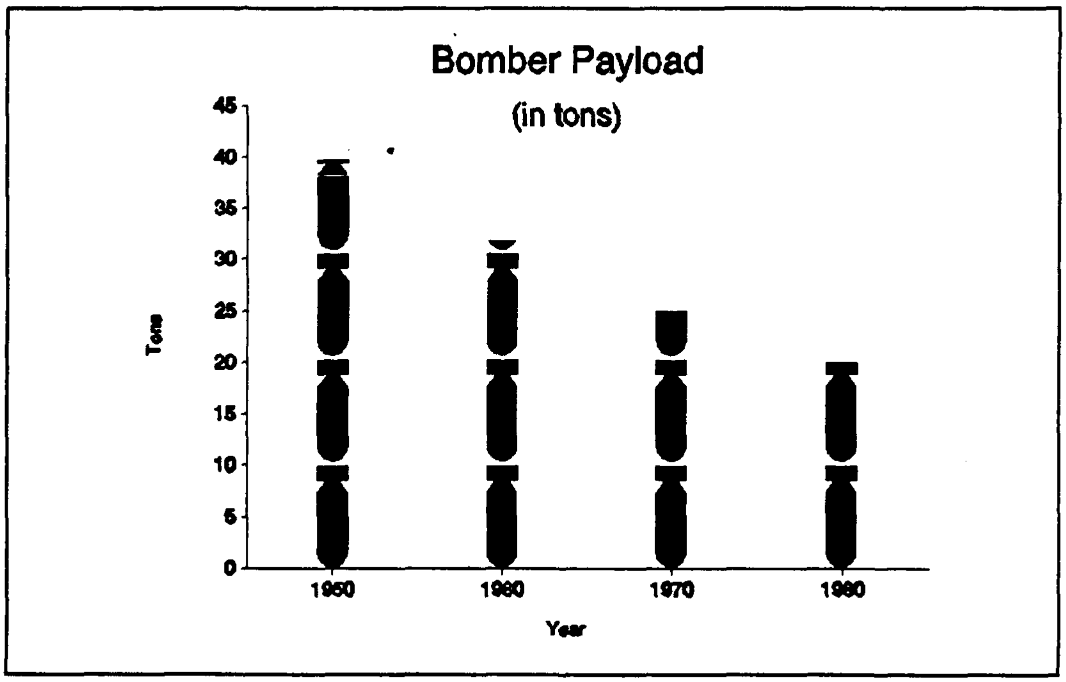


Figure 6b. Multiple Images to Represent Value Changes

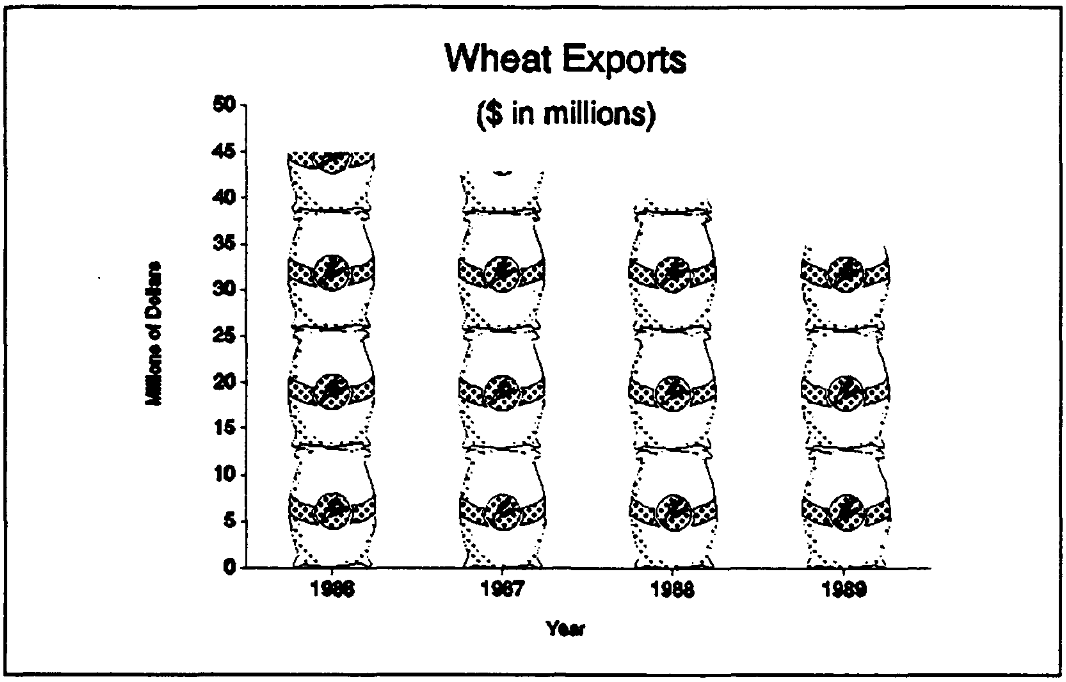


Figure 7a. Lack of Numeric Values in Chart

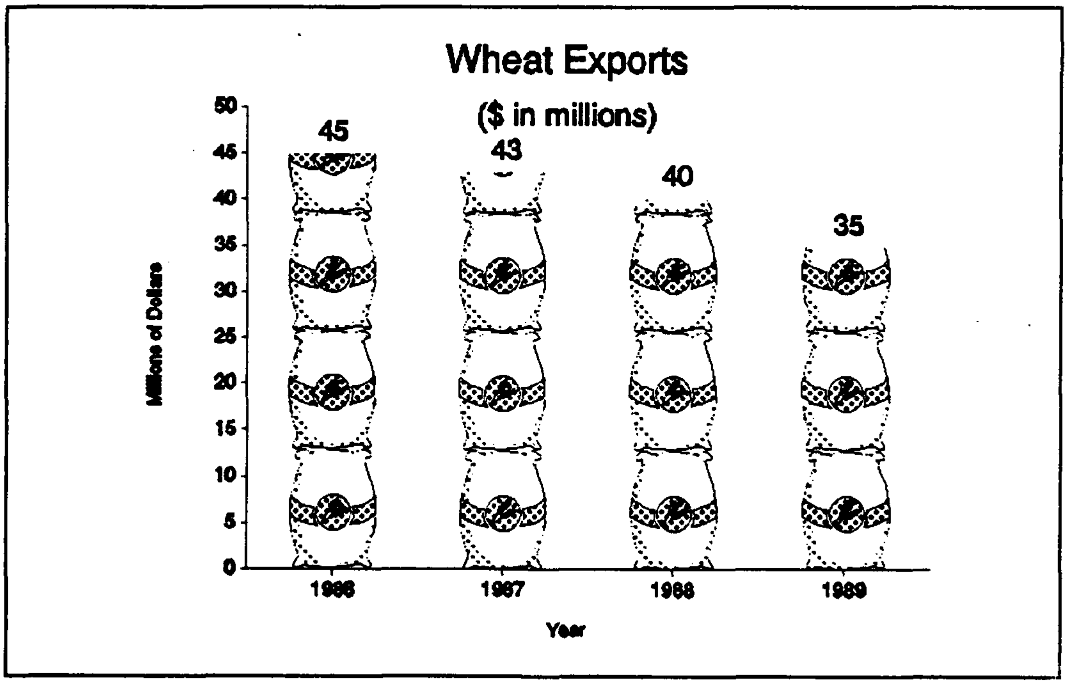


Figure 7b. Use of Numeric Values in Chart

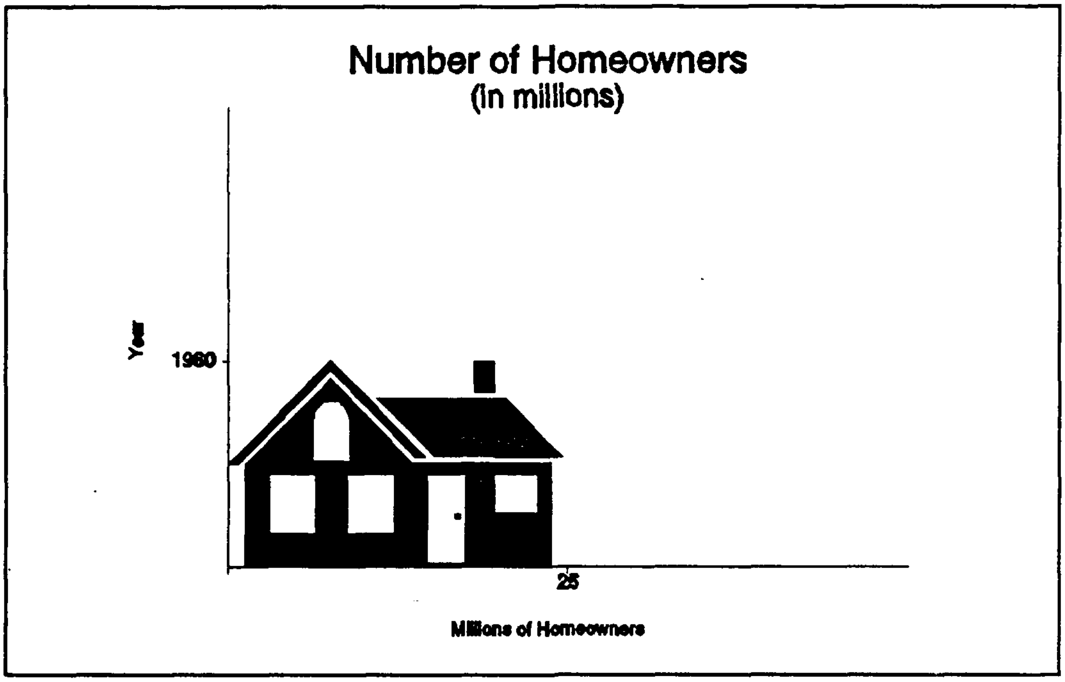


Figure 8a. Use of Iconic Image as a Statement

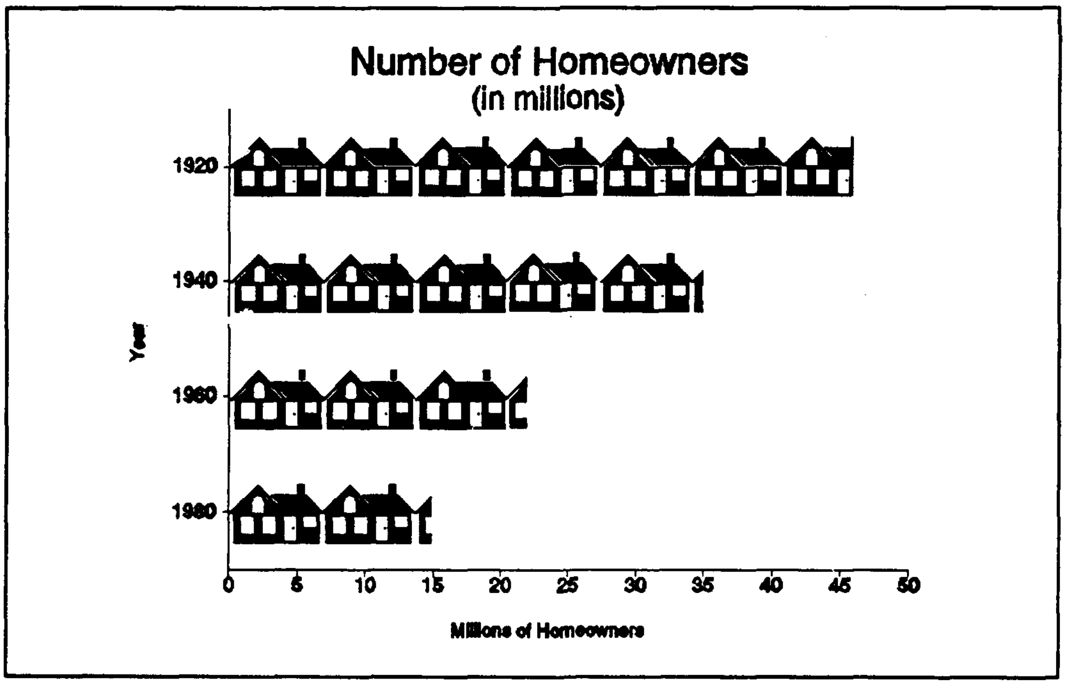


Figure 8b. Use of Iconic Image for Trends

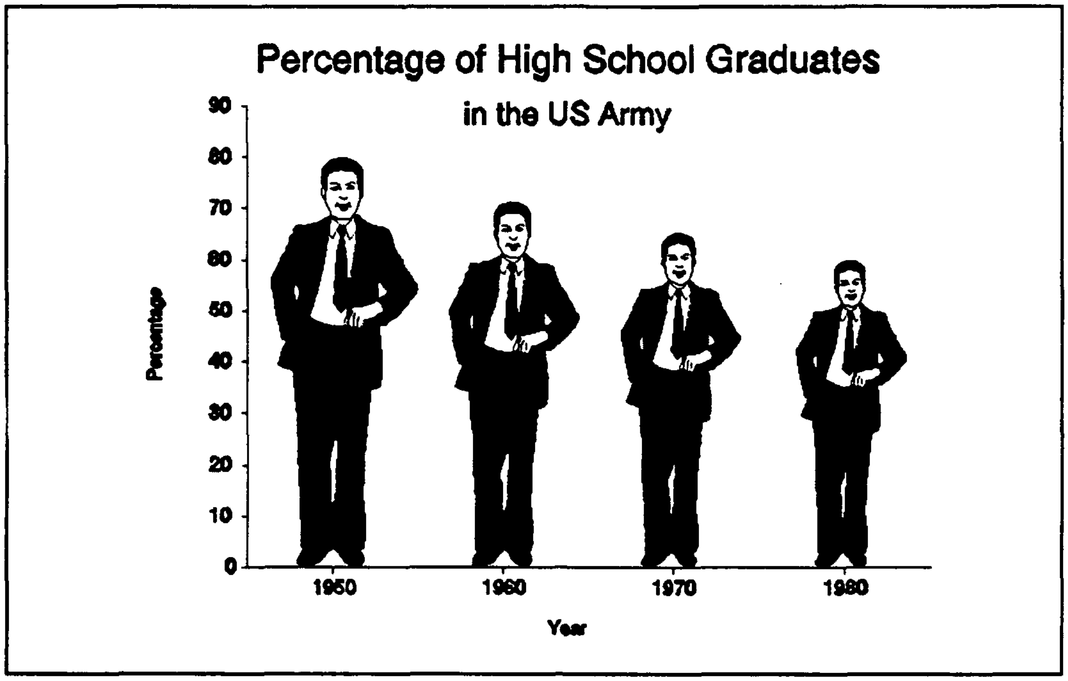


Figure 9a. Use of Detailed Icon

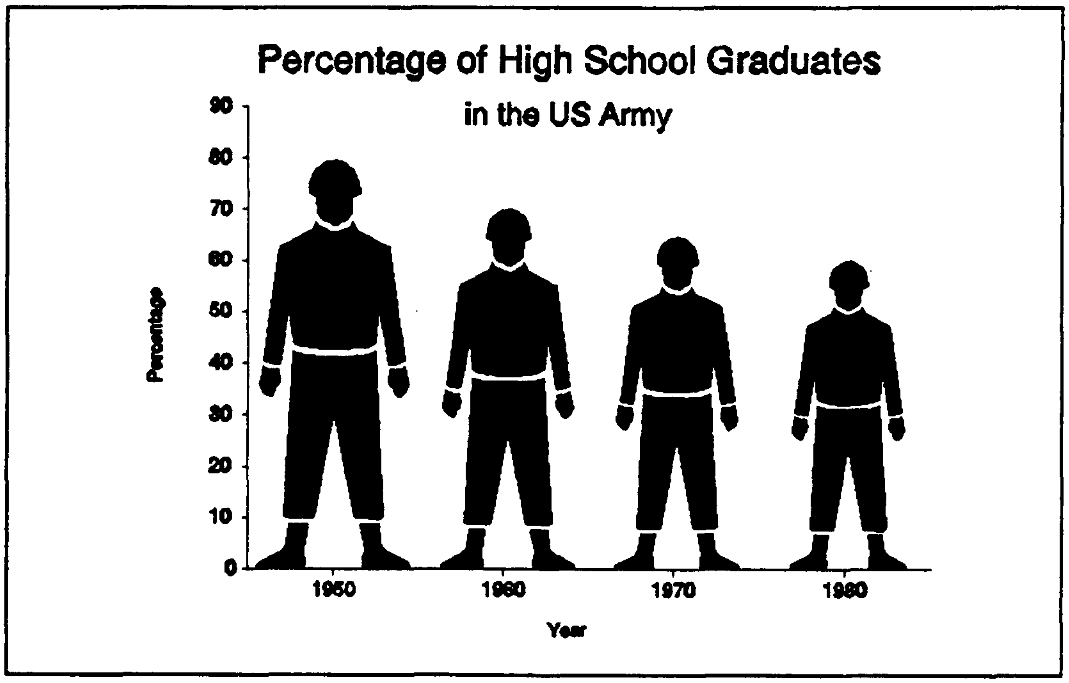


Figure 9b. Use of Simplified Icon

overload", impairing a viewer's ability to interpret a graph (Blattner, Sumikawa, and Greenburg, 1989:12). In order to prevent miscommunication, Modley and Lowenstein have provided seven additional guidelines for choosing and constructing an iconic symbol:

1. Use principles of good design when drawing a pictorial symbol.
2. The symbol should be usable in either large or small size.
3. The symbol should represent a general concept and not an individual of the species.
4. The symbol must be clearly distinguishable from every other symbol.
5. The symbol should be interesting.
6. The symbol is a counting unit and must belear as such.
7. The symbol must be usable in outline as well as silhouette. (Modley and Lowenstein, 1952:47)

These guidelines are still recommended today (Blattner, Sumikawa, and Greenburg, 1989; DeSanctis, 1984; Easterby, 1970). The guidelines provided by Modley and Lowenstein were first written in the 1930s. There is no mention of any formal research done by them. It is unknown if the guidelines presented by them are empirically grounded.

Another graphic display method involves multivariate data. Many variables can be represented by one figure such as a face. A series of these faces could be used to indicate several trends at the same time. This form of graphical display is not considered an icon for the purposes of this experiment, but a study done by MacKay and

Villarreal did find that women were more successful at processing facial cues than men (MacKay and Villarreal, 1987:544). Even though most research did not indicate a difference between the ability of men and women to interpret pictures, we felt that this finding may be a factor in iconic graphs. Since there has been no research as yet on the possible gender bias of iconic graphs, this is an area worthy of additional investigation.

Human Interaction with Graphics

Previous studies have shown that the ability of a person to interpret graphs can be affected by his personality, cognitive style, and attitudes (Davis, 1981; Lusk and Dersnick, 1979; Robey, 1983; Zmud, Blocher, and Moffie, 1983). Davis (1981) performed a study based on the Myers-Briggs Type Indicator Test. This study found that "Thinking" types made better decisions using graphics, "Sensing-Feeling" types made better decisions using tabular data, and "Intuitive" types used either format with equal skill.

Research of cognitive theory suggests that verbal and visual images are interpreted and stored using different parts of the brain. This phenomenon has been called the "dual-code theory". According to this theory, the human brain is divided into two parts: the left and right hemispheres. Each of these hemispheres performs a specific function during information processing. The left hemisphere performs logic related functions such as analytical thought. Problem solving is performed sequentially based on the facts presented. Imagination, receptivity, and impulsive behavior originate in the right hemisphere. Based on this theory, graphical images would be processed more by the right hemisphere. This also suggests that people with a dominant right-brain would benefit more from graphs than people with a dominant left-brain (DeSanctis, 1984:479).

Another theory has surfaced known as the "propositional theory". This theory presumes that information is stored as an abstract image. Information is held in short-term memory and is gradually transformed into an abstract image. The image is formed based on the meaning of the information presented. Pictures can be held longer in short-term memory than verbal information (DeSanctis, 1984:479).

Other Graphical Considerations

While software packages have had a considerable impact in the evolution of graphic presentation, it is the evolution of printer capabilities along with the reduction in prices of printers that have made the evolution possible (Dennis, 1988:17). Color printers have added a new dimension to what a novice user with a graphics package can do. It has not been demonstrated that the use of color will improve an individual's ability to find and interpret information, but poor use of color could have adverse impacts on these abilities (Ives, 1982:18). As a result of the inconclusive evidence of color, the graphs used in this study will contain no color.

Another important variable in area graphs such as bar graphs is the "lie factor". This factor is used to determine the amount of data distortion found in area graphs. It is a ratio of the change in the area of the graphic to the change in the data.

$$\text{Lie Factor} = \frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}} \qquad (1)$$

Factors higher than one exaggerate trends and factors below one understate trends. Factors exceeding 1 ± .05 are considered misleading (Tufte, 1983:57).

A graphical consideration originally addressed by Modley and Lowenstein involves the fractionalizing of a symbol. They feel that it is usually better to round off the figures so the reader does not have to be concerned with decimal changes. However, for graph accuracy, fractions may be employed (Modley and Lowenstein, 1952:56). Of course, Modley and Lowenstein made this observation before the computer age. Now icons can be broken down into incredibly smaller fractions than once dreamed possible, making it even more difficult for the reader to determine the actual number represented by the symbol. In this study, fractions were used so that the height and/or length of the icon bar would be exactly the same as its corresponding traditional bar.

Finally, the emotionality of an icon was considered. Introducing an icon that might elicit an emotional response instead of an honest interpretation of the data was minimized. However, icons were used in our masked graphs that might be considered emotional. Chapter IV contains some of the responses given by the subjects on this topic.

Future Problems

Throughout the research on graphics there has been one common problem. That problem is the ability of untrained persons to design graphics presentations without regard to proper graphics procedures. For example, the graphics package used in this study was DrawPerfect 1.1. The basic graphic program did not start the dependent axis at zero and let the scale extend too far beyond the highest points on the graph. It takes someone who knows the guidelines for proper graphics presentation and the knowledge to adapt the program to insure an accurate result.

During our time at AFIT, we have paid close attention to the graphs used by fellow students and our instructors. We also reviewed popular newspapers and journals for the graphics they publish. The lack of training is evident. Slick graphics that emphasize what the creator wants and not what the data says abound. For now, it is up to the reader/decision-maker to decipher the graph and not make a decision based solely on the picture.

Conclusion

While there have been recommendations as to how to present icons in graphs, there has been very little research into whether or not these recommendations are effective. This gap in the literature provided the impetus for the experiment contained in this thesis. Because of the increased use of iconic graphs by the media and their lack of adherence to graphical guidelines, it is important to determine the impact these presentation methods have on the viewer. Therefore, it is appropriate, from an investigative standpoint, to first examine whether or not the iconic graphs are viewed differently than traditional graphs. Thus, two hypotheses were created to determine if people were able to interpret the data the same way if either traditional or iconic graphs were used, and if people preferred one method of presentation over the other. Since three forms of iconic graphic presentation were used, the same two hypotheses apply to all three methods used. The last hypothesis, as mentioned previously, is a result of findings in previous research.

III. Methodology

The purpose of this research is to compare the impression of an iconic graph to the impression of a traditional graph based on the same data to determine whether people interpret iconic graphs differently than traditional graphs. This chapter describes the experimental design. The validity of the pretest-posttest design and its historical accuracy will be discussed. Next, there will be a discussion of construction of the experiment, characteristics of the population, and the selection of the sample. Next will be a description of the equipment used and support required to administer the experiment and analyze the results. The chapter will end with an explanation of the analysis that will be used to accept or reject the hypotheses. The hypotheses are:

1a. Iconic graphic area manipulation will not affect a person's impression of a graph.

1b. There is no preferential difference between iconic graphic area manipulation and traditional graphs.

2a. Horizontal iconic graphs will not affect a person's impression of a graph.

2b. There is no preferential difference between horizontal iconic graphs and traditional graphs.

3a. Vertical iconic graphs will not affect a person's impression of a graph.

3b. There is no preferential difference between vertical iconic graphs and traditional graphs.

4. Gender will not affect the impression of the iconic graphs.

The purpose of hypotheses 1a, 2a, and 3a was to test whether the impression of an iconic graph is different from the impression of a traditional graph. Because three forms of iconic graphs were used, three hypotheses were required. The purpose of hypotheses 1b, 2b, and 3b was to determine if an individual preferred an iconic presentation method or a traditional presentation method. Here again, three hypotheses were required due to the three iconic presentation methods. The purpose of hypothesis 4 is to determine whether gender affects the results of any of the previous hypotheses.

Experimental Design

To test the hypotheses, a pretest-posttest design was used (Emory, 1991:431).

$$\text{Control:} \quad R\ O_1 \quad\ O_2$$
$$\text{Experimental:} \quad R\ O_1\ x\ O_2$$

This design was chosen primarily because of its use on previous research pertaining to graphics (Kern, 1991 and Larkin, 1990). The R's represent the random assignment of subjects to the control ($O_1 \quad O_2$) and experimental (O_3 x O_4) groups. The x in the experimental group represents the manipulation of the independent variable. O_1 and O_3 represent the pretest portion of the experiment. In the pretest both groups viewed the same graphs. O_2 and O_4 represent the posttest. In the posttest the control group received an additional set of graphs like the ones presented in the pretest. The experimental group received a treated version of the additional graphs. The effect (E) of the treatment is determined by the following formula (Emory, 1991:431):

$$E = (O_2 - O_1) - (O_4 - O_3) \qquad (2)$$

Experimental Subjects

The population of this experiment is the general public, since everyone is now exposed to iconic graphics whether it be in school textbooks, the media, or at work. Professional Continuing Education (PCE) and graduate students have been used to represent the general public in the past. In this experiment, PCE and graduate students were the primary sources of sample subjects. The experiment was also administered outside the AFIT environment, to offices assigned to Air Force Materiel Command. The PCE and graduate classes selected for the sample were dependent on course director and instructor approval, availability, and schedule. Specific classes were not targeted for the sample. While a convenience sample is considered the least reliable design (Emory, 1991:274), it has been acceptable for previous experiments. Also, by not targeting specific courses the sample will include a broader base of the population (military officers and enlisted personnel, DOD civilians, and defense contractors).

Internal Validity of the Pretest-Posttest Design

An advantage of this experimental design is its high internal validity. Internal validity tests the experiment's ability to estimate the relationship of the tested variables. The seven major threats to internal validity are:

1. History - the affect of outside events that may influence the relationship being studied.

2. Maturation - Factors dealing with the passage of time that may influence the subject's response like boredom or hunger.

3. Testing - the experience gained in taking the first test may influence the results of the second test.

4. Instrumentation - Differences in the implementation of the experiment can effect the results.

5. Selection - Subjects should be randomly assigned to experimental and control groups unless there is another factor that is being measured that requires the two groups to be balanced such as differences between sex or experience level.

6. Statistical Regression - Subjects should not be selected based on extreme scores. The sample should mirror the population.

7. Experimental Mortality - When an experiment is conducted over a long period of time, the sample group may change. For example, a study of employee attitudes may be affected by people leaving the company or new employees. (Emory, 1991:424-427)

For this experiment, history will not be a factor because the posttest will be administered immediately after the pretest, not allowing for outside events. The experiment took less than 20 minutes to administer, thus reducing the effects of maturation. Testing was not a factor because the subjects took the pretest and posttest at the same sitting. The structure and content of the measurement questions were constant throughout the test instrument. The experiment was administered using notebooks and grease pencils. The familiarity of these items reduced the instrumentation threat.

Subjects were randomly assigned to the experimental and control groups, reducing the threat of selection. According to Stanley and Campbell, randomization also controls many factors causing problems in experimental design (Stanley and Campbell, 1966:23-24). Statistical regression is not a factor because of the use of a random sample. Mortality is not a factor because of the short duration of the experiment.

<u>External Validity of the Pretest-Posttest Design</u>

External validity determines whether the relationship can be generalized across the entire population over an extended period of time. There are four main threats to external validity:

1. Reactivity of Testing on X - Sensitizing the subjects by a pretest that could cause them to answer differently in the posttest.

2. Interaction of Selection and X - By selecting samples from a narrow slice of a population, the ability of the results to reflect behaviors of other members of the population is reduced.

3. Experimental Setting Biases - Laboratory experiments may bias the results of the test because the subjects know they are being watched. There is also the possibility of subjects trying to game the experiment.

4. Multiple-Treatment Inference - When subjects are repeatedly tested, the effects of prior testing cannot be erased and may affect responses in the current testing cycle. (Emory, 1991:427-428; Campbell and Stanley, 1966:5-6)

The experimental and control groups received the same pretest graphs, reducing the possibility of different sensitization between these two groups. There was sensitization between the pretest and posttest because the pretest and posttest graphs have the same titles. Since the graphs were randomized, it was possible for a subject to have the last pretest graph and first posttest graph contain the same title. The effects of selection can be reduced through randomization. In the execution of this experiment, the subjects were employees of federal governments (United States and Australian). This may pose a problem if these groups of people perceive graphics in a different way than their commercial counterparts. In an effort to reduce the effects of this confound, subjects were selected from local offices, in addition to the PCE students and graduate students at the Air Force Institute of Technology, to broaden the base of the sample. Historically, college students have been used to represent the general public. The effects of experimental bias were reduced because the experiment was conducted in the subjects' classroom. However, there may be a limitation because the subjects knew that they were being tested. Multiple-treatment inference was not a factor in this experiment since the subjects were only tested once.

Content validity measures the ability of the instrument to cover the area of study (Emory, 1991:180). The three forms of iconic graphs being evaluated in this experiment are represented twice in the experimental group. This covers the content requirement without making the experiment too lengthy. Another means of insuring content validity is our use of research methods students in the pre-test. By getting other opinions as to the design and content of the instrument, content validity is strengthened.

Replicability is a measure of the reproducibility of the experiment. The values used to create all the graphs used in this experiment can be found in Appendix A. Any individual using DrawPerfect 1.1 and this data will be able to reproduce the graphs provided proper rules for graphic design are followed. In addition to the reproduction of the graphs, another researcher would also have to use the same measurement questions, time limits, and provide the same initial instructions. Since the experiment would have to be exactly replicated, replicability is a limitation. The reliability of the experiment is unknown since there has been no other test of this instrument. Reliability refers to the consistency of subject responses over time.

Construction of the Experiment

In order to use the pretest-posttest design, ensure sufficient data points within the experiment, and mask what was being tested, twenty-four graphs had to be constructed. To construct the graphs, DrawPerfect 1.1 was chosen because of its compatibility with WordPerfect and its availability on the AFIT computer network.

First, the icons available in DrawPerfect were reviewed to see which ones would be suitable for the experiment. Many of the guidelines specified by Modley and Lowenstein were considered during icon selection. About 30 icons were initially selected. Tall, slim icons were required for the size manipulation graphs in order to follow Larkin's recommendations for high-integrity graphs and get four data points on each graph. These icons were used in graphs 7E (pg 86), 11E (pg 98), 14 (pg 103), and 15 (pg 104). Graphs 7E and 11E are pertinent to hypotheses 1a, 1b, and 4. Icons that were easily lined up could be used for the horizontal iconic graphs. These icons were used in graphs 9E (pg 92), 12E (pg 101), 13 (pg 102), and 16 (pg 105). Graphs 9E and 12E are pertinent to hypotheses 2a, 2b, and 4. Icons that were easily stacked could be used for the vertical iconic graphs. These icons were used in graphs 8E (pg 89), 10E (pg 95), 17 (pg 106), and 18 (pg 107). Graphs 8E and 10E are pertinent to hypotheses 3a, 3b, and 4.

In addition to meeting the guidelines specified up by previous researchers and ensuring the icons would fit in the graph, the icon had to lend itself to a suitable title. A total of sixteen iconic graphs was constructed. The six graphs that best met the guidelines and induced the least emotional bias were chosen for the posttest experimental charts. In order to build the iconic graphs in DrawPerfect, a traditional bar chart first had to be constructed. The icons were then placed over the area represented by the bar and the size of the icon was changed to fit the size of the bar. Once the icons were in place, the bar was removed. The traditional charts used to create the icon charts had been saved and these charts were used for the posttest control charts. The control and experimental charts had the same title. The pretest charts were constructed using the same titles, but different input data was used. Six of the remaining ten iconic graphs were chosen for the masked graphs.

Table 1 contains a synopsis of the graphs used in the experiment. The graphs and their input data are listed in Appendix A. For example, in graph 1 the data changes from 85 in 1950 to 77 in 1960. This represents a 9.4% change. The graphs and the percentage change between data points are listed in Appendix B. The percentage changes indicate the severity of the trend.

TABLE 1

EXPERIMENTAL PACKAGE

Pretest-Posttest Charts

Chart Number	Exp	Ctrl	Title	Icon Type
1	7E	7C	High School Graduates in the US Army	Size
2	8E	8C	Wheat Exports	Stack
3	9E	9C	Number of Homeowners	Align
4	10E	10C	Literacy Rate	Stack
5	11E	11C	Percentage of Tools Made in the US	Size
6	12E	12C	Percentage of Domestic Car Sales	Align

Masked Charts

Chart Number	Title	Icon Type
13	Savings as a Percentage of Income	Align
14	Work Related Injuries	Size
15	Bomber Payload	Size
16	US Car Exports	Align
17	Teen Liquor Consumption	Stack
18	Amount of Leisure Time	Stack

In the construction of the experiment, careful consideration has been made regarding variables that, in the past, have been shown to have an impact on graph interpretation. These control issues include:

1. Color, which may or may not affect data interpretation, will not be used.

2. The data will not be deliberately distorted.

3. The use of a notebook experiment removes the variability that a fear of computers might cause.

4. The icons and topics picked to represent the data do not require specialized knowledge.

5. The titles and icons used in the pretest and posttest graphs were selected to minimize any emotional bias in the subjects.

6. The size of the total graph is the same on each page.

7. The intervals used on the measurement axes contain either 10 or 11 increments, and only four data points to provide continuity in graph appearance.

8. The subjects and design used are applicable to the population and not just Air Force personnel.

9. Decision style will not be addressed because the effect iconic graphs have on decision-making is beyond the scope of this study.

Graphs one through six are the pretest graphs. Graphs seven through twelve E are the experimental posttest graphs and seven through twelve C are the control posttest graphs. The masked graphs are thirteen through eighteen. The graphs used in the experiment are contained in Appendix C.

The perceived complexity of the graph could affect a subject's ability to interpret the information presented in the graph (Lusk and Kersnick, 1979:797). Using both positive and negative trends might have been confusing to the experiment participants, so all the graphs used in this experiment have a negative trend.

The Experiment

Prior to administration, a pre-test of the instrument was given to AFIT students who completed the research methods course (COMM 630). These subjects were chosen for the pre-test because of their recent exposure to experimental design. After the experiment, they were asked additional questions regarding length of the experiment and whether or not they felt the instructions were adequate. There was also be a debriefing for any comments not covered by the questionnaire.

The notebooks containing the experiment were handed out to each group of subjects in no particular order. The subjects were instructed to keep the notebooks closed until instructed to begin. Once told they could begin, the subjects were given an unlimited amount of time to read the instructions and the sample measurement questions in order to familiarize them with the experiment. The instruction sheet is included in Appendix C. Also included in the instructions was an explanation of what "very significant" trends and "very insignificant" trends were for the purposes of this study. The subjects were not allowed to use rulers or make any extraneous marks on the test instrument. The instructions informed the students that the data used to generate the graphs are not based on fact and that there can be no wrong answer. There is no mention of icons or traditional graphs so there would be no bias going into the experiment. No questions were answered by the test monitor during the experiment, so the instructions are the only guidelines the subjects received. In this way all subjects in the different groups given the experiment received the same information.

The pretest graphs were the first six graphs in the experiment, but were randomized within themselves. The experimental group next had the six iconic posttest graphs and six masked graphs, randomized together. The control group had their six posttest graphs randomized with the masked charts as well. The organization of the experiment is shown in Table 2.

The experimental group saw six iconic graphs equally split between horizontal, vertical, and area manipulation. The control group graphs were split into two horizontal bars and four vertical bars as was the pretest group of graphs.

Each graph was presented on a separate piece of paper along with the two measurement questions. The measurement questions were at the bottom of each page containing the graph. The first question measures the subject's impression of a graphic trend and the second question measures the subject's preference for the graphic presentation. Each question was answered using a nine point Likert scale.

TABLE 2

EXPERIMENTAL ORGANIZATION

Instructions	
Pretest	
Six randomized pretest graphs	
Posttest	
Six posttest graphs (traditional bar) randomized with six masked (wildcard) graphs	Six posttest graphs (icons) randomized with six masked (wildcard) graphs
Questionnaire	

Likert scales are often used because they are easy to construct (DeVellis, 1991:68 and Emory, 1991:221). Sudman and Bradburn (1982:157) recommend always including an odd number of response categories when constructing Likert scales to account for people who want to take a middle of the road position. For this experiment a nine point Likert scale was chosen over a seven point Likert scale in order to provide more answer options for the subject. People do not normally like picking the extreme options (Emory, 1991:211-212; Guilford, 1954:278), so it was felt that the nine point scale was superior.

Originally, both measurement questions were anchored with "strongly agree" and "strongly disagree", but the subjects taking the pre-test had difficulty understanding the anchors. DeVellis (1991:70) feels that a good Likert scale states "the opinion, attitude, belief, or other construct under study in clear terms." Since the first question was used to measure the severity of a trend the anchors were changed to "very insignificant" and "very significant." The subjects from a second pre-test saw the "very insignificant" and "very significant" anchors and experienced no confusion.

The subjects had 15 seconds to review the graph and answer both questions. Fifteen seconds was chosen because the subject would have only enough time to view the graph and answer the two questions. The responses would be the subjects' quick impressions of the graphs, not well thought out decisions. The test monitor instructed the subjects when to turn the page.

<u>Demographic Questionnaire</u>

Following the experiment was a posttest questionnaire to collect demographic data. This questionnaire is also included in Appendix C. Several questions were chosen because they measure individual characteristics that have historically shown an impact on graphics experiments

(Dennis, 1988:22; Lucas, 1981:760; MacKay and Villarreal, 1987:544; and Taylor, 1983:177).

The subjects' sex was needed because one of our hypotheses was based on gender. The age question was included to get a rough idea of the average age of the sample. This question will give an indication of where the subject is in their life/career. Like the age question, the education question indicated the average education level of the sample.

The Rank/Grade question indicated the position within the Air Force and years of service indicated Air Force experience. The supervisory level demonstrates whether the subject is a manager of people. The higher the level, the more complex that individual's job might be from a managerial standpoint. It was necessary to know how often the subject saw an icon or picture used in a graph. People are better able to extract information from graphical formats with which they are familiar (Ives, 1982:21). The brain has a tremendous capacity for processing spatial relationships. When information is presented in a standardized format, the person can effectively locate and interpret the information presented. When a new format is used the person must relearn how to locate the information required to interpret the graph (Ives, 1982:27). Another question asked was whether they used graphs in decision-making.

Because abiding by graphics rules was very important to our construction of the graphs, it was also necessary to know how many subjects had made graphs (of any kind) themselves. Which method of presentation the subjects preferred of the five used in the experiment was asked in case no clear indication was obvious from the responses to the preference question.

Because some emotionally charged icons were included in the masked graphs, it was necessary to know if any of the graphs made the subject feel uneasy. It was also necessary to know if any of the graphs seemed ambiguous. Here again, this was due to the selection of some of the masked icons. Next was a question regarding previous knowledge of the experiment. The last question was reserved for any additional comments the subject might have.

Equipment

In order to actually administer the experiment, certain equipment was required. The experiment package containing the instruction sheet and eighteen graphs was placed in protective sheets. These sheets were housed in a standard, one inch, three ring binder. Twenty-one black binders were used. Eleven contained the experimental package and ten contained the control package. Each package had been randomized as explained earlier and no two books contained graphs in the same order. The demographics questionnaire was placed behind the experiment, but was not put in protective sheets. The filled out questionnaires were saved.

A box of twelve blue grease pencils were halved, and these grease pencils were used by the subjects to mark their responses on the protective sheets. They could use any writing implement for the questionnaire. Pencils were provided if a subject needed one. The experiment notebooks, the notebooks housing the filled out demographic questionnaires, and pencils were all kept in a moving box that could be carried by one person. The notebooks, protective sheets, and grease pencils were purchased at local stores. To clean the protective sheets between uses, ordinary paper towels were used.

As mentioned previously, DrawPerfect 1.1 was used to construct the graphs. WordPerfect 5.1 was used for the instructions, questionnaire, and writing contained in this thesis. Quattro Pro 4.0 was used to perform the statistical analyses and build the data tables in this thesis. Statgraphics was used to perform a cross check on the analysis. The computer used to run these software packages was a 386SX-20 Mhz system and the printer used was a Hewlett Packard Laserjet IIP. Because of the sophistication of the graphs and the necessity of a quality product, a deskjet or laserjet printer is recommended for replication of the graphs.

Support

In addition to analysis assistance and guidance from our thesis committee, support was also received from graduate and PCE instructors in getting subjects for the pre-test of the experiment. Graduate and PCE classes were used for subjects.

All reproduction for the experiment was done at commercial facilities to insure a quality product. The transfer of subject responses to data collection sheets and the computer for analysis, the randomization of graphs, cleaning of the protective sheets, and insertion of new demographic questionnaires was performed by this research team. Other students, already familiar with this experiment, assisted in cleaning the protective sheets.

Analysis

To test hypotheses 1, 2, and 3, the following formulae were used:

Null hypothesis: The use of icons does not affect the impression left by a graph.

$$H_o: \ (O_2 - O_1) - (O_4 - O_3) = 0$$

Alternative hypothesis: The use of icons does affect the impression left by a graph.

$$H_a: \ (O_2 - O_1) - (O_4 - O_3) \neq 0$$

To test hypothesis 4, the following formulae were used:

Null hypothesis: Gender does not affect the impression left by a graph.

$$H_o: (O_2 - O_1) - (O_4 - O_3) = 0$$

Alternative hypothesis: Gender does affect the impression left by a graph.

$$H_a: (O_2 - O_1) - (O_4 - O_3) \neq 0$$

The six titles used for the pretest graphs are the same six titles used for the posttest graphs. The formulae used for hypotheses 1, 2, and 3 were used for each set of graphs (by title), thus making it possible to separate the three forms of iconic graphs being presented. The formulae used for hypothesis 4 were used to compare the total pretest and posttest responses, as well as the sets of charts as explained for hypotheses 1, 2, and 3. For this hypothesis the male and female responses were analyzed separately. Data were collected from 99 subjects. Forty-nine subjects were in the control group and 50 were in the experimental group. Some subject responses could not be used for all of the hypothesis tests. These observations were deleted from the data set prior to analysis. The subjects were reevaluated after each hypothesis test to determine whether they could be used for the next hypothesis tested. By reevaluating the entire data set for each hypothesis, the maximum number of subjects could be considered for each test. With eighteen graphs in each set and two questions for each graph, there were over 3500 data points to analyze.

There are two categories of statistical tests: parametric and nonparametric. Of the two,

> Parametric tests are the more powerful because their data are derived from interval and ratio measurements. Nonparametric tests are used to test hypotheses with nominal and ordinal data. Parametric techniques are the tests of choice if their assumptions are met. (Emory, 1991:529)

The following assumptions must be met to use a parametric test:

1. The observations must be independent.
2. The observations should be drawn from normally distributed populations.
3. These populations should have equal variances.
4. The measurement scales should be at least interval so that arithmetic operations can be used with them.
5. The means of these normal and homoscedastic populations must be linear combinations of effects due to columns and/or rows. (The effects must be additive) (Emory, 1991:529-530 and Siegel, 1956:19)

If these conditions are met, the t statistic will be used (Emory, 1991:533). If the conditions are not met, the Mann-Whitney U test will be used (Emory, 1991:574). Even though nonparametric tests are not as powerful as parametric tests, increasing the sample size of a nonparametric test will allow the researcher to attain the power of parametric tests (Hammond and Householder, 1962:375). Because the sample size of this experiment was 99, the Mann-Whitney test is just as powerful as the t statistic test. For either test the significance level will be $\alpha = .05$. This level was selected because it facilitates comparisons with previous graphics experiments that normally reported results at the .05 level of significance. Additionally, even though there is no steadfast rule for selecting significance levels, the conventional levels are .05 and .01 (Henkel, 1976:77-78). Nonparametric statistical tests have several advantages over parametric tests. These advantages are:

> 1. Probability statements from most tests are exact probabilities, regardless of the shape of the population distribution.
>
> 2. They must be used for very small sample sizes ($n < 7$) unless the population distribution is known exactly.
>
> 3. Samples can contain observations from several different populations.
>
> 4. They can be used for data that are classified as "more or less" without need of a number defining "more or less".
>
> 5. They can be used to measure data in a nominal scale.
>
> 6. They are much easier to learn and apply than parametric tests. (Siegel, 1956:32-33)

There are disadvantages to using a nonparametric model. The first, and perhaps most important, is that

> If all the assumptions of the parametric statistical model are in fact met in the data, and if the measurement is of the required strength, then nonparametric statistical tests are wasteful of data. The degree of wastefulness is expressed

by the power-efficiency of the nonparametric test. (Siegel, 1956:33)

The Mann-Whitney test ". . .is one of the most powerful of the nonparametric tests, and it is a most useful alternative to the parametric t test when the researcher wishes to avoid the t test's assumptions. . ." (Siegel, 1956:116). If the Mann-Whitney test is properly used, its power-efficiency approaches 95 percent for even moderate-sized samples (Siegel, 1956:126). The power of a test is its ability to reject the null hypothesis. The power of a test is always equal to or greater than the significance level (Henkel, 1986:81).

The other disadvantage is that there is no way to test for interactions in the analysis of the variance model without special additivity assumptions. This is not seen as a tremendous disadvantage because parametric models must use the same assumptions (Siegel, 1956:33).

In this experiment, two matrices were developed: pretest vs. posttest trend responses, and pretest vs. posttest presentation preference responses.

A test for normality was conducted on the pretest-posttest data using The Kolmogrov-Smirnov two-sample test (Siegel, 1956:131). The critical value for the Kolmogrov-Smirnov two-sample test (D_{crit}) is compared to the maximum difference between the cumulative frequency distributions of the two samples being tested (D). Eq (3) is used to calculate the critical value for the Kolmogrov-Smirnov two-

$$D_{crit} = 1.36 \sqrt{[(x_1 + x_2)/x_1 x_2]}$$

where

D_{crit} = Critical value for the Kolmogorov-Smirnov two-sample test
x_1 = size of the first group
x_2 = size of the second group (3)

sample test and Eq (4) is used to calculate D. The procedure for finding D will be discussed in the following section. If $D < D_{crit}$, the samples are normally distributed. All charts must be normally distributed to use the parametric tests.

$$S_{x1}(X) = K_1/x_1$$

$$S_{x2}(X) = K_2/x_2$$

$$D = \max[S_{x1}(X) - S_{x2}(X)]$$

where

$S_{x1}(X)$ = cumulative step function of first sample
$S_{x2}(X)$ = cumulative step function of first sample
X = Interval step
K_1 = observations $\leq X$ in the first group
K_2 = observations $\leq X$ in the second group
D = maximum value of $S_{x1}(X) - S_{x2}(X)$ (4)

To test for the equality of variances between the two groups, the F ratio was used. The variables s_x^2 and s_y^2 are the variances of the two groups. The larger variance is assigned as s_x^2 and the smaller value is assigned as s_y^2.

As a result, the F ratio is always greater than or equal to one.

$$F = s_x^2/s_y^2 \tag{5}$$

The degrees of freedom for each group are equal to the number of observations in each group minus one. If the F ratio calculated is less than the F value found in the statistical tables at the 95 percent level of confidence, the variances are equal.

Example Analysis

Tables 3 and 4 will be used to illustrate the calculations required for the analysis of the experimental data. The observations are listed numerically with 31 observations in the control group and 30 in the experimental group. Pretest charts for both groups are listed as charts 1 through 6 and the posttest charts are listed as 7 through 12. Totals for both groups are included. The difference between the pretest total and posttest total is listed in the "Diff" column. The "Rank" column contains the Mann-Whitney ranking which will be explained in the following pages.

TABLE 3

CONTROL GROUP CHARTS

Obs	O1 Pretest Chart # 1	2	3	4	5	6	Tot	O2 Posttest Chart # 7	8	9	10	11	12	Tot	Diff	Rank
1	2	4	7	7	3	6	29	3	3	8	6	2	1	23	6	53
2	7	7	7	8	7	7	43	7	8	9	6	9	7	46	-3	18.5
3	3	4	6	6	3	4	26	6	2	7	6	4	3	28	-2	27
4	6	7	8	8	4	6	39	7	5	7	7	7	7	40	-1	31.5
5	6	5	5	6	3	6	31	7	4	6	6	7	6	36	-5	3
6	7	6	6	9	3	2	33	8	2	6	7	2	2	27	6	53
7	6	7	6	7	5	6	37	6	3	8	6	5	6	34	3	46
8	5	1	5	1	5	6	23	2	5	6	6	5	3	27	-4	9.5
9	8	6	8	6	3	3	34	8	3	8	7	3	3	32	2	43.5
10	2	4	7	7	3	6	29	3	3	8	6	2	1	23	6	53
11	7	7	7	8	7	7	43	7	8	9	6	9	7	46	-3	18.5
12	3	4	6	6	3	4	26	6	2	7	6	4	3	28	-2	27
13	6	7	8	8	5	5	39	7	5	7	7	7	7	40	-1	31.5
14	6	5	5	6	3	6	31	6	3	5	5	6	5	30	1	40
15	6	5	5	8	2	1	27	8	2	6	7	2	2	27	0	35
16	6	7	6	7	5	6	37	6	3	8	6	5	6	34	3	46
17	5	1	5	1	5	6	23	2	5	6	6	5	3	27	-4	9.5
18	8	6	8	6	3	3	34	8	3	8	7	3	3	32	2	43.5
19	2	4	7	7	3	6	29	3	3	8	6	2	1	23	6	53
20	7	7	7	8	7	7	43	7	8	9	6	9	7	46	-3	18.5
21	3	4	6	6	3	4	26	6	2	7	6	4	3	28	-2	27
22	6	7	8	8	5	6	40	7	5	7	7	7	7	40	0	35
23	6	5	5	6	3	6	31	7	4	6	6	7	6	36	-5	3
24	6	4	6	9	3	2	30	8	2	8	7	2	2	29	1	40
25	6	7	6	7	5	6	37	6	3	8	6	5	6	34	3	46
26	5	1	5	1	5	6	23	2	5	6	6	5	3	27	-4	9.5
27	7	5	7	5	2	2	28	8	3	8	7	3	3	32	-4	9.5
28	2	4	7	7	3	6	29	3	3	8	6	2	1	23	6	53
29	7	7	7	8	7	7	43	7	8	9	6	9	7	46	-3	18.5
30	3	4	6	6	3	4	26	6	2	7	6	4	3	28	-2	27
31	5	1	5	1	5	6	23	2	5	6	6	5	3	27	-4	9.5
T1															-7	938.5

TABLE 4

EXPERIMENTAL GROUP CHARTS

O	O3 Pretest Chart #							O4 Posttest Chart#								
Obs	1	2	3	4	5	6	Tot	7	8	9	10	11	12	Tot	Diff	Rank
32	5	1	4	4	2	5	21	5	3	6	4	6	2	26	-5	3
33	7	7	6	7	6	7	40	5	5	6	6	7	4	33	7	57
34	6	6	6	6	5	6	35	6	6	7	6	6	6	37	-2	27
35	5	7	5	7	2	7	33	6	6	7	6	1	6	32	1	40
36	5	6	7	6	5	7	36	6	5	8	7	7	6	39	-3	18.5
37	7	2	8	9	2	1	29	7	2	8	8	3	1	29	0	35
38	8	7	6	7	3	7	38	8	6	9	7	4	8	42	-4	9.5
39	3	2	7	9	3	4	28	4	7	8	7	3	2	31	-3	18.5
40	6	6	6	6	6	6	36	3	6	7	6	2	1	25	11	60
41	9	1	9	9	3	7	38	7	3	9	9	3	3	34	4	49
42	5	1	4	4	2	5	21	5	3	6	4	6	2	26	-5	3
43	7	7	6	7	6	7	40	5	5	6	6	7	4	33	7	57
44	6	6	6	6	5	6	35	6	6	7	6	6	6	37	-2	27
45	5	7	5	7	2	7	33	6	6	7	6	1	6	32	1	40
46	5	6	7	6	5	7	36	6	5	8	7	7	6	39	-3	18.5
47	7	2	8	9	2	1	29	7	2	8	8	3	1	29	0	35
48	8	7	6	7	3	7	38	8	6	9	7	4	8	42	-4	9.5
49	3	2	7	9	3	4	28	4	7	8	7	3	2	31	-3	18.5
50	6	6	6	6	6	6	36	3	6	7	6	2	1	25	11	60
51	9	1	9	9	3	7	38	7	3	9	9	3	3	34	4	49
52	5	1	4	4	2	5	21	5	3	6	4	6	2	26	-5	3
53	7	7	6	7	6	7	40	5	5	6	6	7	4	33	7	57
54	6	6	6	6	5	6	35	6	6	7	6	6	6	37	-2	27
55	5	7	5	7	2	7	33	6	6	7	6	1	6	32	1	40
56	5	6	7	6	5	7	36	6	5	8	7	7	6	39	-3	18.5
57	7	2	8	9	2	1	29	7	2	8	8	3	1	29	0	35
58	7	6	5	6	2	6	32	7	5	8	6	3	7	36	-4	9.5
59	3	2	7	9	3	4	28	4	7	8	7	3	2	31	-3	18.5
60	6	6	6	6	6	6	36	3	6	7	6	2	1	25	11	60
61	9	1	9	9	3	7	38	7	3	9	9	3	3	34	4	49
T1															18	952.5

The first step is to determine whether a parametric test can be used in testing the hypotheses. To do this, the normality of the sample and equality of the variances for the control and experimental groups must be verified. The normality of the sample is determined using the Kolmogorov-Smirnov test. A cumulative frequency distribution is created for the experimental and control groups based on the "Diff" value found in Tables 3 and 4. The distributions for the two groups must have the same interval. The value D is the largest difference found between the two distributions. Table 5 contains the cumulative frequency distribution data for this example. To make this example easier to illustrate, the last observation from the control group was dropped to give the two distributions the same denominator value.

TABLE 5

CUMULATIVE FREQUENCY DISTRIBUTION DATA

	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	11
$S_{x1}(X)$	$\frac{2}{30}$	$\frac{6}{30}$	$\frac{10}{30}$	$\frac{14}{30}$	$\frac{16}{30}$	$\frac{18}{30}$	$\frac{20}{30}$	$\frac{22}{30}$	$\frac{25}{30}$	$\frac{25}{30}$	$\frac{25}{30}$	$\frac{30}{30}$	$\frac{30}{30}$	$\frac{30}{30}$
$S_{x2}(X)$	$\frac{3}{30}$	$\frac{6}{30}$	$\frac{12}{30}$	$\frac{15}{30}$	$\frac{15}{30}$	$\frac{18}{30}$	$\frac{21}{30}$	$\frac{21}{30}$	$\frac{21}{30}$	$\frac{24}{30}$	$\frac{24}{30}$	$\frac{24}{30}$	$\frac{27}{30}$	$\frac{30}{30}$
$S_{x1}(X) - S_{x2}(X)$	$\frac{-1}{30}$	$\frac{0}{30}$	$\frac{-2}{30}$	$\frac{-1}{30}$	$\frac{1}{30}$	$\frac{0}{30}$	$\frac{-1}{30}$	$\frac{1}{30}$	$\frac{4}{30}$	$\frac{1}{30}$	$\frac{1}{30}$	$\frac{6}{30}$	$\frac{3}{30}$	$\frac{0}{30}$

The top row contains the interval steps (X) for the cumulative distribution of the two groups. The interval is

based on the "Diff" values. The $S_{x1}(X)$ value for the step interval -1 is the ratio of all observations with a "Diff" value ≤ -1 in the first group. For example, $S_{x1}(X)$ at -1 would be 16/30. The same convention is used for $S_{x2}(X)$ on the second group. This value would be 15/30 at -1. The last row of numbers is the difference between $S_{x1}(X)$ and $S_{x2}(X)$. For interval -1 this value would be 1/30.
Based on Table 5, D=6/30 or 0.2. The D_{crit} value can be calculated using Eq (3).

$$D_{crit} = 1.36 \sqrt{[(30 + 30)/(30 * 30)]}$$
$$= .3512$$

Since $D < D_{crit}$, the populations are normally distributed. Next, verify the equality of the sample variances using Eq (5).

$$F = s_x^2/s_y^2$$
$$= 25.48966/13.31398$$
$$= 1.914503$$

Since the tables did not include an F_{crit} value for df = 30, 29, the value for df = 30, 30 was used. As a result, F_{crit} = 2.07 at α = 0.05. Since $F < F_{crit}$, the sample variances are equal.

The two tests performed above gave results that would allow the use of parametric hypothesis testing. In this thesis both the parametric and nonparametric tests were used to test the hypotheses unless one of the tests was rejected. The t-statistic, will be illustrated first. Because the two samples do not contain the same number of observations, a pooled variance (s^2) must be calculated for the t-statistic:

$$s^2 = \frac{\Sigma d_1^{\ 2} + \Sigma d_2^{\ 2}}{(n_1 - 1) + (n_2 - 1)}$$

where

d_1 = Diff of the smaller group
d_2 = Diff of the larger group
n_1 = Smaller group size
n_2 = Larger group size (6)

$$s^2 = \frac{\Sigma d_1^{\ 2} + \Sigma d_2^{\ 2}}{(n_1 - 1) + (n_2 - 1)}$$

$$= \frac{750 + 401}{29 + 30}$$

$$= 19.50847$$

The value from Eq (6) then used to calculate the standard deviation of the differences (s_{diff}).

$$s_{diff} = \sqrt{s^2[(n_1 + n_2)/(n_1 n_2)]} \tag{7}$$

$$= \sqrt{19.50847\ [(30 + 31)/(30 * 31)]}$$

$$= 1.131189$$

The t-statistic for samples of unequal size is calculated as follows:

$$t = (\bar{d}_1 - \bar{d}_2)/S_{diff} \tag{8}$$
$$= [.6 - (-.23)]/1.131189$$
$$= .73003$$

Looking at the statistical tables, $t_{crit} = 2.0010$ at $\alpha = .05$ and df = 59. The degrees of freedom equal $n_1 + n_2 - 2$ because this is the value used to determine the pooled variance. Since $t < t_{crit}$, H_o would be accepted.

The calculation of the Mann-Whitney U value is the next step. This nonparametric technique requires the ranking all of the observations according to their "Diff" values, in ascending order. The lowest "Diff" value is given a ranking of one. If there are multiple observations with the same "Diff" value, the tied observations are given the ranking of the midpoint of all tied observations. Looking at the data, there are five observations with a "Diff" value of negative five, the lowest "Diff" value. The rank for all five of these observations would be three. The Mann-Whitney U statistic incorporates the summation of the rankings from the smallest group or the group that gives the smallest U value:

$$U = n_1 n_2 + [n_1(n_1 + 1)]/2 - R_1$$

or

$$U = n_1 n_2 + [n_2(n_2 + 1)]/2 - R_2$$

where

R_1 = Sum of rankings for the smaller group
R_2 = Sum of rankings for the larger group (9)

$$= (30)(31) + [(30)(31)]/2 - 952.5$$

$$= 442.5$$

A T value is calculated for each of the multiple observation groups and summarized. For example, in the group with a "Diff" value of negative five, the T value would be the difference of five cubed minus five divided by twelve:

$$\Sigma T = \Sigma(m^3 - m)/12$$

where m = # of multiple observation in a group (10)

$$= 2(2^3 - 2)/12 + 4(3^3 - 3)/12 + 4(5^3 - 5)/12 + 3(7^3 - 7)/12 + (8^3 - 8)/12 + (10^3 - 10)/12$$

$$= 201.5$$

The final step for the nonparametric test is to calculate the equivalent of a z-statistic using the values of U and T computed above:

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{n_1 n_2/N(N - 1)((N^3 - N)/12) - \Sigma T}}$$

where

N = total # of observations (11)

$$= \frac{442.5 \quad - (30)(31)/2}{\sqrt{(30)(31)/(61)(60)[(61^3 - 61)/12 - 201.5]}}$$

$$= -.32633$$

Using a z table, the p-value for $z = -.33$ is $1 - .6293$ or .3707. If the z table is one-tailed table, as the one used here, the p-value above must be doubled. If $\alpha <$ p-value, the null hypothesis is accepted. With a p-value of .7414, H_o is accepted.

The data collected from the experiment are included in Appendix D. The "Diff" values are included in Appendix E. The analysis described in this chapter was used to evaluate the data and the results of that analysis are included in Chapter IV. Because the sample size was large and the Mann-Whitney statistic is considered to be as powerful as a t-statistic for large samples, the Mann-Whitney was the primary test statistic with the t-statistic used as a backup when the parametric assumptions were met.

IV. Analysis and Findings

Three forms of iconic graphs were used in this experiment. Each graphic form had a two part hypothesis that was tested. In addition, there is a fourth hypothesis concerning differences in gender bias. This chapter contains the data obtained in the experiment and the analysis of that data. There will also be some additional analyses based on findings unrelated to the hypotheses that may be of interest to future researchers in this area.

Experimental Results

Experimental hypotheses 1a, 2a, and 3a were:

H_o: $(O_2 - O_1) - (O_4 - O_3) = 0$; The use of icons does not affect the impression left by a graph.

H_a: $(O_2 - O_1) - (O_4 - O_3) \neq 0$; The use of icons does affect the impression left by a graph.

Experimental hypotheses 1b, 2b, and 3b were:

H_o: $(O_2 - O_1) - (O_4 - O_3) = 0$; Subjects have no preference between iconic graphs and traditional graphs.

H_a: $(O_2 - O_1) - (O_4 - O_3) \neq 0$; Subjects have a preference between iconic graphs and traditional graphs.

Experimental hypothesis 4 was:

H_o: $(O_2 - O_1) - (O_4 - O_3) = 0$; Gender does not affect an individual's impression of a graph.

H_a: $(O_2 - O_1) - (O_4 - O_3) \neq 0$; Gender does affect an individual's impression of a graph.

In hypothesis 4, the males and females were divided into separate groups to perform the analysis. The results from the two groups were compared.

Table 6 lists how the charts will be sorted to test each hypothesis. For example, hypothesis 1a included only the responses from the first question, the one concerning trend interpretation. Responses from the control group charts 7 and 11 were combined to form O_2. Responses from the control group charts 1 and 5 were combined to form O_1. Responses from the experimental group charts 7 and 11 were combined to form O_4. Responses from the experimental group charts 1 and 5 were combined to form O_3. O_1, O_2, O_3, and O_4 were then used to test the hypotheses.

The statistical analysis method was described in Chapter III. The results of the hypotheses tests are included in Tables 7 and 8. Table 7 contains the results from the nonparametric tests and Table 8 contains the results from the parametric tests. For example, hypothesis

TABLE 6

HYPOTHESES BY CHART

H_o	Control Group Charts		Experimental Group Charts
1	[(7 + 11) - (1 + 5)]	-	[(7 + 11) - (1 + 5)]
2	[(9 + 12) - (3 + 6)]	-	[(9 + 12) - (3 + 6)]
3	[(8 + 10) - (2 + 4)]	-	[(8 + 10) - (2 + 4)]
4	(tot posttest - tot pretest)	-	(tot posttest - tot pretest)

1a, 2a, and 3a: Used responses from the 1st question.

1b, 2b, and 3b: Used responses from the 2nd question.

4: Used responses from the 1st question. Male and female responses were calculated separately and the results compared.

TABLE 7

NONPARAMETRIC TESTING RESULTS

H_o	Subject	R	U	ΣT	z	p
1a	Size	2454.0	1122.0	876.0	-.56	.5754
1b	Size	2657.0	632.5	952.0	-3.59	.0004
2a	Aligned	2290.0	990.0	1456.0	-.80	.4438
2b	Aligned	2299.5	943.5	1078.5	-.90	.3682
3a	Stacked	2368.0	1112.0	814.5	-.30	.7642
3b	Stacked	2479.0	626.0	837.5	-3.27	.0012
4	Male	916.5	446.5	194.0	-.25	.8026
	Female	185.5	96.5	14.0	-.24	.8104

1a, the size manipulation hypothesis, had an R value of 2454, a U value of 1122, and a ΣT of 876. Based on these values the z statistic is -.56. The resulting p-value is

TABLE 8

PARAMETRIC TESTING RESULTS

H_o	Subject	D_{crit}	D	F	Δd	t
1a	Size	.2748	.1458	1.092	.44	.548
1b	Size	.281	.1975	3.141	2.57	N/A
2a	Aligned	.2806	.2246	1.567	-.21	-.328
2b	Aligned	.2836	.2293	1.397	.51	.511
3a	Stacked	.2776	.1460	1.191	-.30	-.316
3b	Stacked	.2852	.1784	1.716	2.00	2.738
4	Male	.3487	.1030	2.477	0	N/A
	Female	.5128	.1176	1.959	-1.99	-.607

.5754, hence H_o is accepted. The parametric results give a D_{crit} of .2748 and a D value of 7/48 or .1458. Since $D \leq D_{crit}$, the distributions are considered normal. The F ratio is 1.092, below the F_{crit} value of 1.6147 found in the statistical tables, allowing the assumption of equal variances. The next column is titled Δd, the difference between the two average "Diff" values. The t-statistic of .548 is below the t_{crit} value of 1.984 where n = 100, and $\alpha = .05$.

Analysis of Data

In hypotheses 1a, 2a, 2b, 3a, and 4 H_o would be accepted using either the t-statistic or the Mann-Whitney tests. The F ratio for hypothesis 1b showed the samples to have unequal variances, so only the Mann-Whitney test was used. Based on the z-statistic, H_o was rejected.

Hypothesis 3b produced a t-statistic and a z-statistic higher than the critical value, allowing rejection of H_o.

The data for each pair of charts are included in Tables 9 and 10. The first set of six chart pairs reflect the data from the first (trend) question, and the second set of six chart pairs reflect the data from the second (preference) question. The rest of the tables are read the same as Tables 7 and 8. Each of the charts were acceptable according to the trend results, but the preference results rejected three of the charts. The analysis of charts 1 and 7 (High School Graduates in the US Army) showed rejection, but the other set of size manipulation charts, charts 5 and

TABLE 9

ADDITIONAL NONPARAMETRIC RESULTS

Cht	Subject	R	U	ΣT	z	p
	Trend					
All						
1/7	Size	2541.0	1223.0	2232.0	-.476	.6312
2/8	Stacked	2402.0	1126.0	2177.0	-.366	.7114
3/9	Aligned	2402.0	982.0	6118.0	-1.137	.2542
4/10	Stacked	2450.0	1176.0	2178.5	-.177	.8572
5/11	Size	2551.0	1124.0	1681.5	-.714	.4778
6/12	Aligned	2635.0	991.0	3634.0	-1.524	.1286
	Pref					
All						
1/7	Size	2702.0	633.0	3228.5	-3.765	.0002
2/8	Stacked	2581.0	756.0	1818.5	-2.671	.0076
3/9	Aligned	2170.5	1072.5	2494.0	-.067	.9442
4/10	Stacked	2675.5	755.5	3004.5	-2.963	.0030
5/11	Size	2688.0	938.0	2840.0	-1.899	.0574
6/12	Aligned	2547.0	981.0	3298.5	-1.439	.1498

TABLE 10

ADDITIONAL PARAMETRIC RESULTS

Cht	Subject	D_{crit}	D	F	Δd	t
	Trend					
1/7	Size	.2748	.0740	1.3444	.14	-.350
2/8	Stacked	.2762	.0859	1.0635	9.69	-.069
3/9	Aligned	.2791	.0625	4.5308	-3.11	N/A
4/10	Stacked	.2748	.1224	1.5916	8.58	-.128
5/11	Size	.2734	.1180	1.2792	.43	.600
6/12	Aligned	.2748	.1837	1.6571	.45	N/A
	Pref					
All						
1/7	Size	.2792	.2520	2.1677	-1.34	N/A
2/8	Stacked	.2805	.1702	1.1137	1.15	2.266
3/9	Aligned	.2821	.2303	1.2600	-.07	-.152
4/10	Stacked	.2777	.2623	1.2365	1.12	.776
5/11	Size	.2748	.2857	1.9760	1.49	N/A
6/12	Aligned	.2762	.1063	1.8097	1.49	N/A

11 (Percentage of Tools Made in the US) showed acceptance, albeit narrowly. Both of the stacked iconic graphs were rejected, and both of the aligned graphs were accepted.

The t-statistic did not prove to be an adequate check for this set of since five of the twelve sets of charts did not meet the assumptions for the use of parametric tests. All five were found to have unequal variances. In addition, the preference results for charts 5 and 11 did not follow a normal distribution. The F_{crit} used for Tables 8 and 10 was 1.6147. The t_{crit} used for Tables 8 and 10 was 1.9867.

Tables 11 and 12 provides additional analysis for hypothesis 4. The males and females were analyzed separately in this set of tables results. These tables are also read the same as Tables 7 and 8. These results showed that gender did not affect the interpretation of the three forms of iconic graphs used in this experiment which is consistant with the overall results. The preference analysis, however, demonstrated a difference between males and females. The results of the male group were consistant with the results of the entire group, but the female group only rejected charts 1 and 7 (High School Graduates in the US Army). Hypothesis 1b was also rejected when the value for U fell below the critical U value according to a Mann-Whitney table for small samples (Seigel, 1956:276).

As a result of the gender analysis, it is obvious that there is a difference between males and females regarding stacked icons. Males do have a preference for traditional bar graphs over stacked icons, and women do not.

Once again, the t-statistic proved frustrating due to the requirements of parametric testing. One-third of the tests were not applicable for use by the t-statistic due to the parametric assumptions not being met. Ten of the tests did not have equal variances and one did not have a normal distribution. The F_{crit}s used for Table 12 were 1.8409 for the males and 2.3526 for the females. The t_{crit}s used for Table 12 were 2.0 for the males and 2.042 for the females.

TABLE 11

ADDITIONAL GENDER NONPARAMETRIC RESULTS

Test	Subject	R	U	ΣT	z	p
	Trend					
Male						
H_o1	Size	1098.0	447.0	467.5	-1.210	.2262
H_o2	Aligned	1144.5	439.5	708.0	-.984	.3270
H_o3	Stacked	1010.5	504.5	283.0	-.271	.7872
1/7	Size	1222.5	523.5	1029.0	-.217	.8258
2/8	Stacked	1017.5	497.5	698.0	-.368	.7114
3/9	Aligned	1261.5	387.5	2435.5	-1.940	.0524
4/10	Stacked	1277.0	505.0	969.0	-.680	.4966
5/11	Size	1145.5	466.5	606.5	-1.170	.2440
6/12	Aligned	1115.5	465.5	1330.5	-1.018	.3078
Fem						
H_o1	Size	246.0	111.0	22.0	-.572	.5686
H_o2	Aligned	206.5	105.5	30.0	-.209	.8336
H_o3	Stacked	291.0	114.0	36.0	-.121	.9044
1/7	Size	251.5	105.5	60.5	-.788	.4296
2/8	Stacked	306.0	117.0	82.5	-.347	.7264
3/9	Aligned	218.0	94.0	82.0	-.704	.4840
4/10	Stacked	296.0	109.0	121.0	-.328	.7414
5/11	Size	232.0	125.0	90.0	-.039	.9680
6/12	Aligned	320.0	103.0	118.5	-.893	.3734
	Pref					
Male						
H_o1	Size	1099.0	287.5	215.5	-2.820	.0048
H_o2	Aligned	1033.0	392.0	414.5	-1.250	.2112
H_o3	Stacked	1152.0	333.0	314.0	-2.400	.0164
1/7	Size	1082.0	304.0	838.5	-2.626	.0086
2/8	Stacked	1138.0	347.0	554.5	-2.221	.0264
3/9	Aligned	980.5	474.5	799.0	-.288	.7718
4/10	Stacked	1240.0	372.0	978.0	-2.386	.0168
5/11	Size	1257.0	355.0	1011.5	-2.606	.0076
6/12	Aligned	1118.0	463.0	747.5	-1.038	.2984
Fem						
H_o1	Size	335.5	69.5	41.0	-1.920	.0548
H_o2	Aligned	207.5	104.5	37.5	-.250	.8026
H_o3	Stacked	247.0	53.0	29.5	-1.820	.0688
1/7	Size	361.5	61.5	176.0	-2.533	.0114
2/8	Stacked	289.0	85.0	96.5	-1.091	.2758
3/9	Aligned	215.0	97.0	89.0	-.577	.5620
4/10	Stacked	275.5	68.5	94.5	-1.590	.1118
5/11	Size	333.0	72.0	95.5	-1.837	.0658
6/12	Aligned	299.5	91.5	211.5	-1.141	.2542

TABLE 12

ADDITIONAL GENDER PARAMETRIC RESULTS

Test	Subject	D_{crit}	D	F	Δd	t
	Trend					
Male						
H_o1	Size	.3362	.1440	1.027	.700	.891
H_o2	Aligned	.3402	.2678	1.296	-.300	-.458
H_o3	Stacked	.3384	.2048	1.032	-.436	-.384
1/7	Size	.3362	.0833	1.236	.020	.046
2/8	Stacked	.3384	.1000	1.240	.090	.128
3/9	Aligned	.3377	.1440	1.360	-.736	-1.560
4/10	Stacked	.3332	.1326	1.011	-.476	-.934
5/11	Size	.3332	.1192	1.474	.620	.866
6/12	Aligned	.3354	.1014	1.035	.624	1.409
Fem						
H_o1	Size	.4846	.1111	1.297	-.700	-.378
H_o2	Aligned	.5011	.1765	4.386	-.700	N/A
H_o3	Stacked	.4950	.1750	1.811	.107	.058
1/7	Size	.4846	.1190	1.517	-.675	-.779
2/8	Stacked	.4846	.2222	1.809	-.350	-.265
3/9	Aligned	.5011	.1584	2.396	-1.050	N/A
4/10	Stacked	.4950	.1111	3.631	.800	N/A
5/11	Size	.4846	.2860	1.276	.010	.006
6/12	Aligned	.4846	.1349	4.583	.321	N/A
	Pref					
Male						
H_o1	Size	.3450	.1571	1.691	.880	2.647
H_o2	Aligned	.3460	.2750	1.973	.842	N/A
H_o3	Stacked	.3410	.2333	1.506	1.044	2.046
1/7	Size	.3448	.3571	1.420	.662	N/A
2/8	Stacked	.3407	.1137	1.498	.657	1.954
3/9	Aligned	.3431	.3152	1.527	.520	.233
4/10	Stacked	.3332	.2527	1.290	.578	1.813
5/11	Size	.3332	.2894	1.358	.686	2.235
6/12	Aligned	.3354	.1548	2.225	.554	N/A
Fem						
H_o1	Size	.4950	.2778	11.310	1.470	N/A
H_o2	Aligned	.5010	.2941	1.181	1.497	.073
H_o3	Stacked	.5270	.1830	2.631	1.287	N/A
1/7	Size	.4846	.3333	5.649	.770	N/A
2/8	Stacked	.5011	.3348	1.963	.791	1.024
3/9	Aligned	.5011	.0950	1.186	1.065	-.425
4/10	Stacked	.5078	.2837	1.130	.757	1.429
5/11	Size	.4950	.3120	5.525	.871	N/A
6/12	Aligned	.4908	.2227	1.048	.722	.937

In two of the tests, the Mann-Whitney test rejected where the t-statistic accepted (Male preference charts 2 and 8 and charts 4 and 10), however the t-statistic just barely allows acceptance. The Mann-Whitney test was our primary statistic for reasons stated in Chapter III, so we used these results when the results conflicted. Because the t-statistic could not be used for all the tests we recommend the use of the Mann-Whitney U test for future research in this area.

Experimental Issues

There were problems in constructing and administering the experiment as well as in the analysis of the data. The problems constructing the experiment were mentioned previously. They were primarily due to the limitations of DrawPerfect. Ideally, there should be a greater icon selection for the types of graphs constructed for this experiment.

The biggest problem encountered during the administration of the experiment involved the equipment. Several subjects missed a graph entirely because static electricity or carelessness caused them to turn two pages at the same time. Another administrative note was the environment during the experiment. The PCE and graduate classes took the experiment in classrooms and were very quiet as though they were taking an academic test. The offices, however, were given the experiment in conference rooms. There was much more noise during the experiment. The noise ranged from giggling to talking aloud.

It was important to this research team to expand the sample to include non-students, and no difference in the data was observed. So the different testing environments had no effect on the overall outcome of the experiment.

Without proper analysis, the experiment itself is meaningless. The data were checked and rechecked to ensure accurate data transfer. The sorting and ranking required by the Mann-Whitney test was also checked numerous times. The formulas used to analyze the data were put into a spreadsheet in Quattro Pro. The equations were also double checked and the results verified manually.

The biggest problem encountered during the analysis was in finding critical values for the test statistics. Due to the large sample size, the degrees of freedom required for a precise critical value was often not included. For example, most F tables jumped from df = 30 to df = 60. Most of the degrees of freedom in this analysis ranged from 10 to 49. Two statistical table books did have more detailed tables. These books, Statistics Tables for Mathematicians, Engineers, Economists, and the Behavioral and Social Sciences by H. R. Neave (1978) and The Handbook of Statistical Tables by Donald Owen (1962), were used in the analysis of the data.

Demographic Information

The sample contained 99 subjects of which 32 were female and 67 were male. Fifty-two of the subjects were between 26 and 35 years of age and 27 were between 36 and 45 years of age. The remaining distributions can be seen in the Demographics Listing in Appendix F. Seventy-nine of the subjects had at least a bachelor's degree. This is not very representative of the Air Force, nor the general population, so it is worth noting. Because of the low number of enlisted and the lack of civilians below GS9, we feel that the education level in our sample is higher than would normally be expected. The largest group from the rank/grade question was junior officers (O-1 through O-3) and equivalently graded civilians (GS9 through GS12).

Fifty-four of the subjects had worked for the Air Force 10 years or less. The age, rank/grade, and years of service questions all demonstrated a younger sample, both in age and experience, than might normally be seen in the workplace.

Fifty-eight of the subjects were not supervisors, and 26 were first level supervisors. As a result, we assumed that our subjects were primarily managers of things and not people. Eighty subjects reported seeing icons/pictures in graphics at least once a week and 51 reported using graphs (of any kind) in decision-making at least twice a month. Seventy-three subjects reported that they constructed graphs for presentations at least once a month. Fifty-nine subjects said they preferred the vertical bar graphs, and 20 said they preferred the horizontal bar graphs. Only 3 subjects stated previous knowledge of the experiment.

Responses to the two open ended questions about whether any of the graphs made the subjects feel uneasy or were ambiguous have also been included in Appendix F. Subjects in both groups felt uneasy about the car exports graph, but they represented less than 10% of the sample. A third of the sample, however, felt the car exports graph was ambiguous. This is worth noting because that graph did violate some of the guidelines let forth in Chapter II. Aircraft carriers were used to represent transoceanic autofreighters. The symbol was not self explanatory and that created ambiguity for the subjects. It was also very hard to determine the trend in this graph, so the actual numbers placed by the icons or the use of smaller icons would have greatly aided interpretation.

Leisure time was also considered ambiguous by more than 10% of the sample. The nature of the icon itself made interpretation difficult. It was one of the most complicated icons used and the intricate detail made it seem busy. Both of these graphs were masked charts which somewhat validates our selection of the icons used in the pretest and posttest charts. The topics and icons used in the pretest-posttest portion of the experiment were listed by less than 10% of the subjects for being ambiguous or making them feel uneasy.

Several subject also included additional comments which we felt should be included with the results. One subject said the topics and graphing techniques were interesting, but another said they did not like the iconic graphs at all. Another said that the scaling of some of the graphs was wrong. (Obviously someone who is used to seeing improperly scaled graphs.) This same subject reported seeing iconic graphs frequently in USA Today and the nightly news and felt our graphs did not add value to the information being presented. Perhaps this is because our graphs did not contain real data.

Another subject stated that the use of percentages on the Y axis is poor and that "15 seconds is too short to assess the effective transfer of information." In chapter III we explained that we only wanted the subjects' first impression of a graph. This subject also feels that the use of icons detracts from the data and emphasized this with the following statement:

> While we live in an era of instant gratification, the use of icons on charts is an extremely banal example of the 'USA Today' mentality forming in paper journalism. We already have the 'sound bite' on TV. Now the use of icons encourages the same thing in journalism.

Two subjects expressed a dislike for size manipulated icons because they felt that this use of icons could be easily manipulated to show whatever the presenter want to emphasize.

Finally, there was one subject who had a lot of previous experience constructing and using graphs. He felt that the graphs with complicated icons made the reviewer focus on the individual icons rather than the overall data being presented. Of the five methods used to present graphic data in this study, he felt the vertical icon bar graphs (such as literacy rate's stacked books) were the hardest to read. He also did not like the horizontal bar graphs. He was not alone. Horizontal bar graphs received the lowest preference ratings. The graphs he felt were the easiest to interpret were the horizontal (aligned) icon graphs, which received high preference ratings.

V. Conclusion

Iconic graphs have become commonplace in today's media. As more software packages include iconic graphic capabilities, their use will become more widespread. Air Force personnel will be faced with these graphs either in their personal life or on the job. Any traditional graphic has the potential of being replaced by icons, so it is necessary to find out whether the graphs will be interpreted in the same manner.

Summary of Results

The three forms of iconic graphs used in this study, size manipulation, aligned icons, and stacked icons, were interpreted the same way the traditional graphs were interpreted, regardless of gender. As a result, data presentation should have no impact on an individual's impression of that data. It is important to note that these graphics followed the graphics guidelines established in prior studies.

While the subjects were able to interpret the data regardless of the presentation method, the majority of the subjects greatly preferred the traditional methods of presentation to the iconic methods. An exception to this was the aligned icons, which were actually preferred to the traditional horizontal bar, though not significantly. In fact, of the three preference hypotheses, the aligned hypothesis was the only one accepted. The size manipulation and stacked icon preference hypotheses were both rejected. Several subjects stated that they did not like the horizontal bar graphs, but they did not mind the rows of houses or cars.

Recommendations for Future Research

While the use of iconic graphs has been made easier due to the proliferation of software packages containing iconic graphics capabilities, they are not very easy to construct correctly. Future research should concentrate on the effect of violating graphic guidelines with iconic graphs. It has been demonstrated (Kern, 1991 and Larkin, 1990) that a decision-maker can be misled by manipulated graphs, and this research needs to be extended into iconic graphs.

This sample for this experiment involved Air Force military or civilian personnel. Different results may be obtained by giving the same experiment to blue-collar workers, housewives, or students at public universities. An additional area worthy of study is decision style. A personality type indicator could be administered before the experiment to determine if decision style has an effect on data interpretation or preference.

Finally, one of the limitations mentioned earlier was that our experiment did not contain color. Increasingly, presentation graphs do contain color and there is no research yet on the effects of color combined with iconic graphs.

Managerial Implications of This Study

As demonstrated in this study, as long as the proper guidelines of high-integrity graphics are used when creating graphs, people should be able to interpret the graphs properly. Anyone constructing graphs, whether they be traditional or iconic, needs to follow these same rules. This makes training a necessity.

When using icons, emotionality must also be considered. The use of emotionally charged icons could provoke an individual into a response contrary to the data's meaning. Since it is not practical to run experiments on every icon to determine emotionality, individuals constructing the graphs must consider the repercussions of the icon choice. Managers, being responsible for the output of their departments, should also check the emotionality of icons used in graphics.

Other experiments (MacKay and Villarreal, 1987) have shown gender to be an important factor in graph interpretation. Had women from a different field been used in this experiment, the results of hypothesis 4 may have been different. There are those who would argue that to work for the military, a woman must "think like a man". While this is far beyond the scope of this study, it should be remembered that it was within a military environment that this study was conducted. Without further validation, the results of the gender hypothesis may be inconclusive.

Consequently replication of this study using a different sample offers a useful area for further inquiry.

Appendix A. List of Graphs: Input Data

Graph #	Title	Graph Type	Data			
			1950	1960	1970	1980
1	High School Graduates	vert	85	77	70	63
7C	in the US Army	vert	80	70	65	60
7E		size				
			1986	1987	1988	1989
2	Wheat Exports	vert	45	35	25	17
8C		vert	45	43	40	35
8E		stack				
			1980	1960	1940	1920
3	Number of Homeowners	horiz	49	40	32	25
9C		horiz	46	35	22	15
9E		align				
			1920	1940	1960	1980
4	Literacy Rate	vert	85	65	45	30
10C		vert	70	60	50	40
10E		stack				
			1950	1960	1970	1980
5	Percentage of Tools	vert	85	80	75	70
11C	made in the US	vert	80	70	60	50
11E		size				
			1950	1960	1970	1980
6	Percentage of Domestic	horiz	80	70	60	50
12C	Car Sales	horiz	85	75	65	60
12E		align				
			1986	1987	1988	1989
13	Savings as a Percentage of Income	align	9.5	8.8	8	7.2
			1950	1960	1970	1980
14	Work Related Injuries	size	27	22	18	12.5
			1950	1960	1970	1980
15	Bomber Payload	size	40	35	25	20
			1986	1987	1988	1989
16	US Car Exports	align	92.5	91.5	90	89
			1950	1960	1970	1980
17	Teen Liquor Consumption	stack	0.9	0.8	0.65	0.5
			1950	1960	1970	1980
18	Amount of Leisure Time	stack	28	27	26.5	25

Appendix B. List of Graphs: Percentage Change

Graph #	Title	Graph Type	Percent Change		
			1960	1970	1980
1	High School Graduates	vert	9.40	9.10	10.0
7C	in the US Army	vert	12.5	7.10	7.70
7E		size			
			1987	1988	1989
2	Wheat Exports	vert	22.2	28.6	32.0
8C		vert	4.40	7.00	12.5
8E		stack			
			1960	1940	1920
3	Number of Homeowners	horiz	18.4	20.0	21.9
9C		horiz	23.9	37.1	31.8
9E		align			
			1940	1960	1980
4	Literacy Rate	vert	23.5	30.8	33.3
10C		vert	14.3	11.7	20.0
10E		stack			
			1960	1970	1980
5	Percentage of Tools	vert	5.90	6.30	6.70
11C	made in the US	vert	14.3	16.7	20.0
11E		size			
			1960	1970	1980
6	Percentage of Domestic	horiz	14.3	16.7	20.0
12C	Car Sales	horiz	11.8	13.3	7.70
12E		align			
			1987	1988	1989
13	Savings as a Percentage of Income	align	7.40	9.10	10.0
			1960	1970	1980
14	Work Related Injuries	size	18.5	18.2	30.6
			1960	1970	1980
15	Bomber Payload	size	12.5	28.6	20.0
			1987	1988	1989
16	US Car Exports	align	1.10	1.60	1.10
			1960	1970	1980
17	Teen Liquor Consumption	stack	11.1	18.7	23.1
			1960	1970	1980
18	Amount of Leisure Time	stack	3.60	1.90	5.70

Appendix C. Experimental Package

Instructions

This experiment is being conducted as part of our graduate thesis for AFIT. You will be looking at a series of 18 graphs. The data used to generate these graphs is not based on fact. The graphs should be reviewed independent of each other. You will be asked two questions pertaining to the information presented in each graph like the following example:

```
The trend in the data has been

1    2    3    4    5    6    7    8    9
|-------------------|-------------------|
Very                                 Very
Insignificant                 Significant


This is a good manner to present this data

1    2    3    4    5    6    7    8    9
|-------------------|-------------------|
Strongly                         Strongly
Disagree                            Agree
```

In this experiment, <u>very significant trends</u> are defined as those that show a large change, not good or bad changes. <u>Very insignificant trends</u> are those that do not show any change.

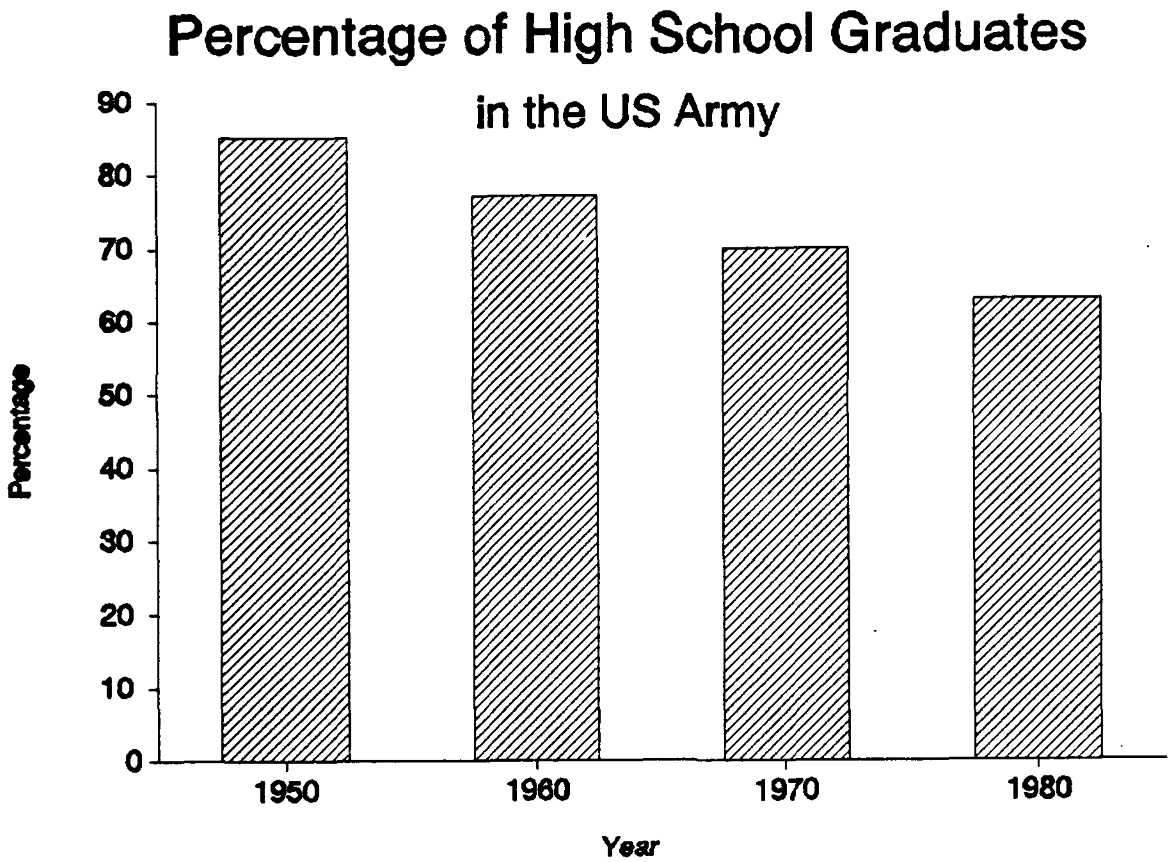
Circle the number corresponding to your answer. Please do not make any other marks on the graphs (i.e., ruler lines). This is not a test and there are no wrong answers.

This will be a timed experiment. You will be given 15 seconds per page to review the graph and answer the two questions. The test monitor will tell you when to go to the next page.

The total length of this experiment should not exceed 20 minutes.

Thank you for your participation.

<u>PLEASE WAIT FOR THE MONITOR TO START THE EXPERIMENT.</u>



The trend of high school graduates in the US Army has been

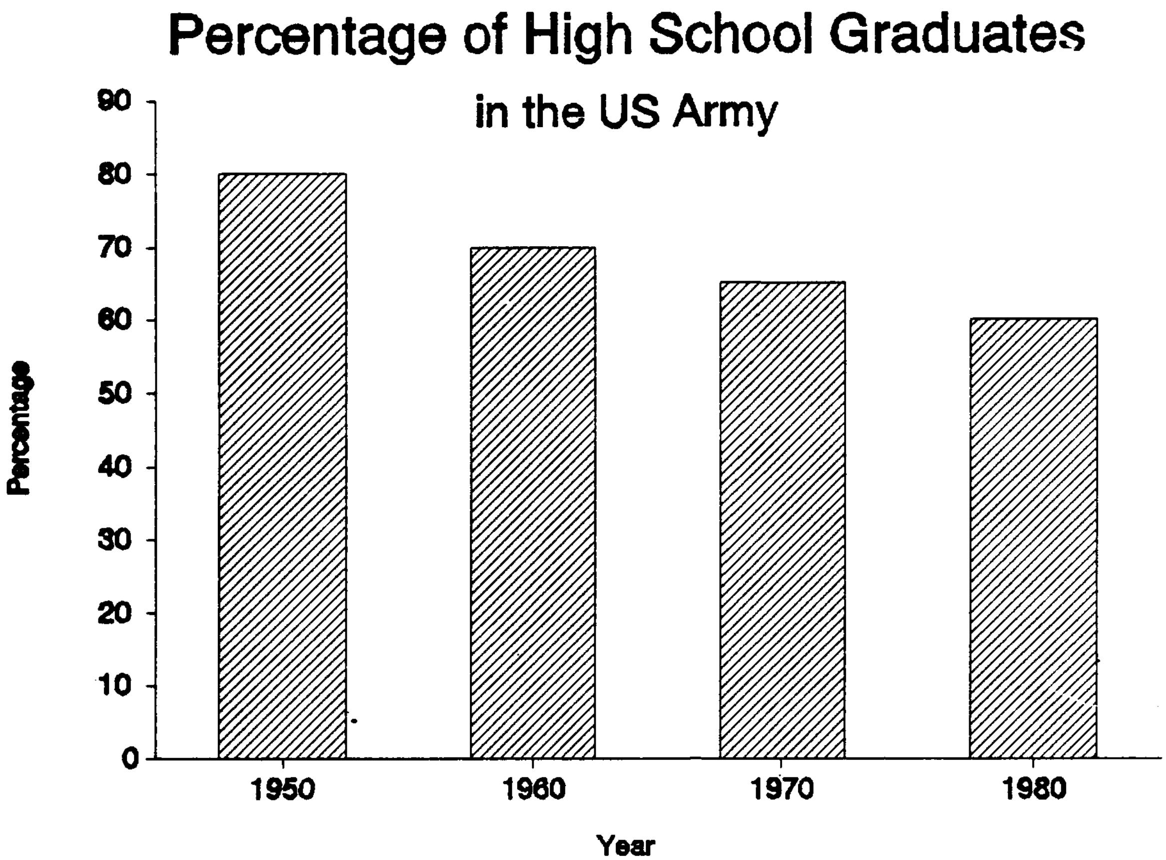
1 2 3 4 5 6 7 8 9

Very Insignificant ... Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree ... Strongly Agree



The trend of high school graduates in the US Army has been

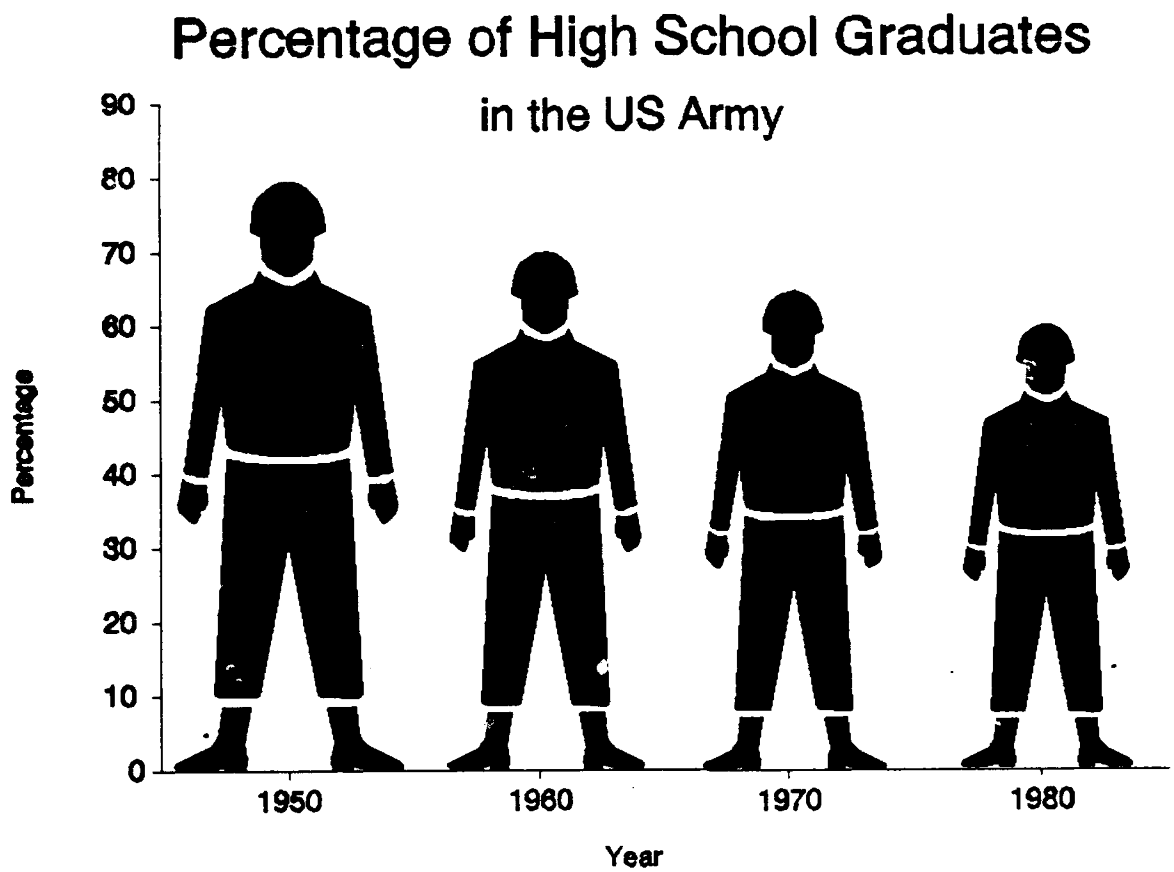
1 2 3 4 5 6 7 8 9

Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree



The trend of high school graduates in the US Army has been

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

Very Insignificant — Very Significant

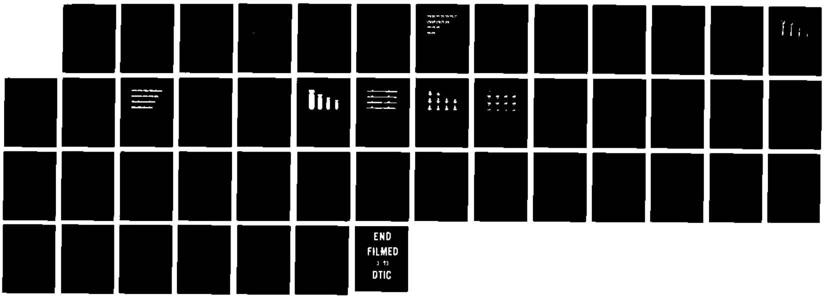
This is a good manner to present this data

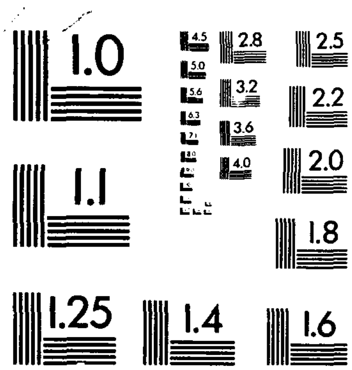
1 2 3 4 5 6 7 8 9

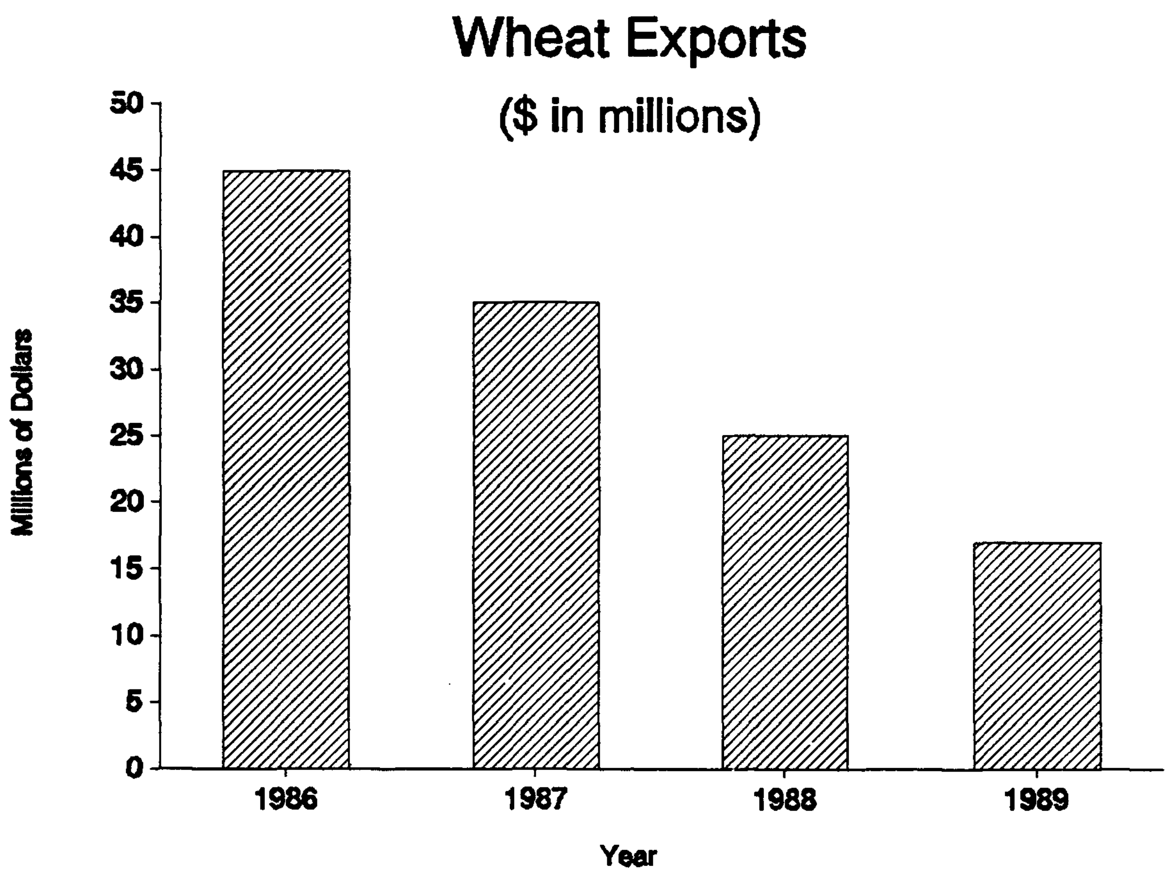
|-------------------------|-------------------------|

Strongly Disagree — Strongly Agree

AD-A250 705 THE EFFECTS OF ICONIC PRESENTATION ON INDIVIDUALS(U) 2/2
AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL
OF SYSTEMS AND LOGISTIC E T BARBER ET AL. SEP 92
UNCLASSIFIED AFIT/GCA/LSY/92S-1 XC-AFIT NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3



The trend in wheat exports has been

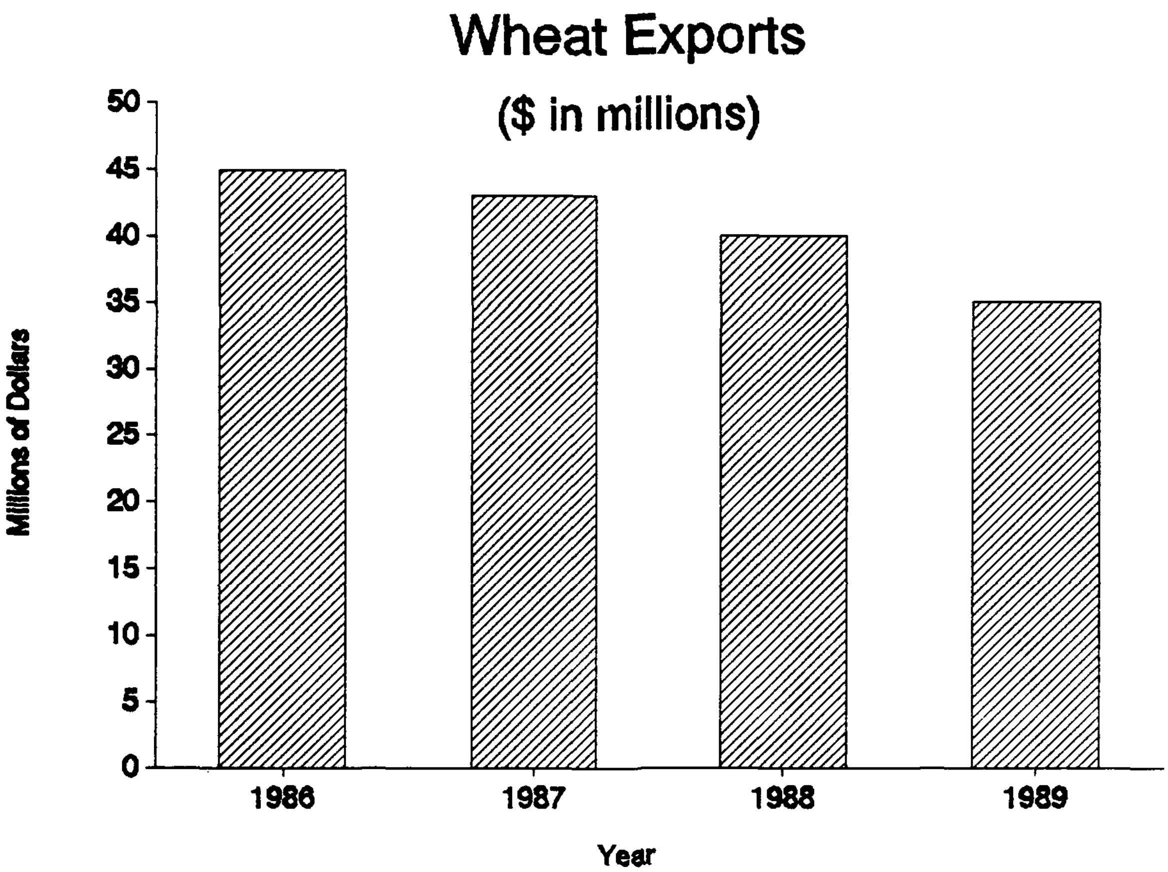
1 2 3 4 5 6 7 8 9

Very Insignificant ... Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree ... Strongly Agree



The trend in wheat exports has been

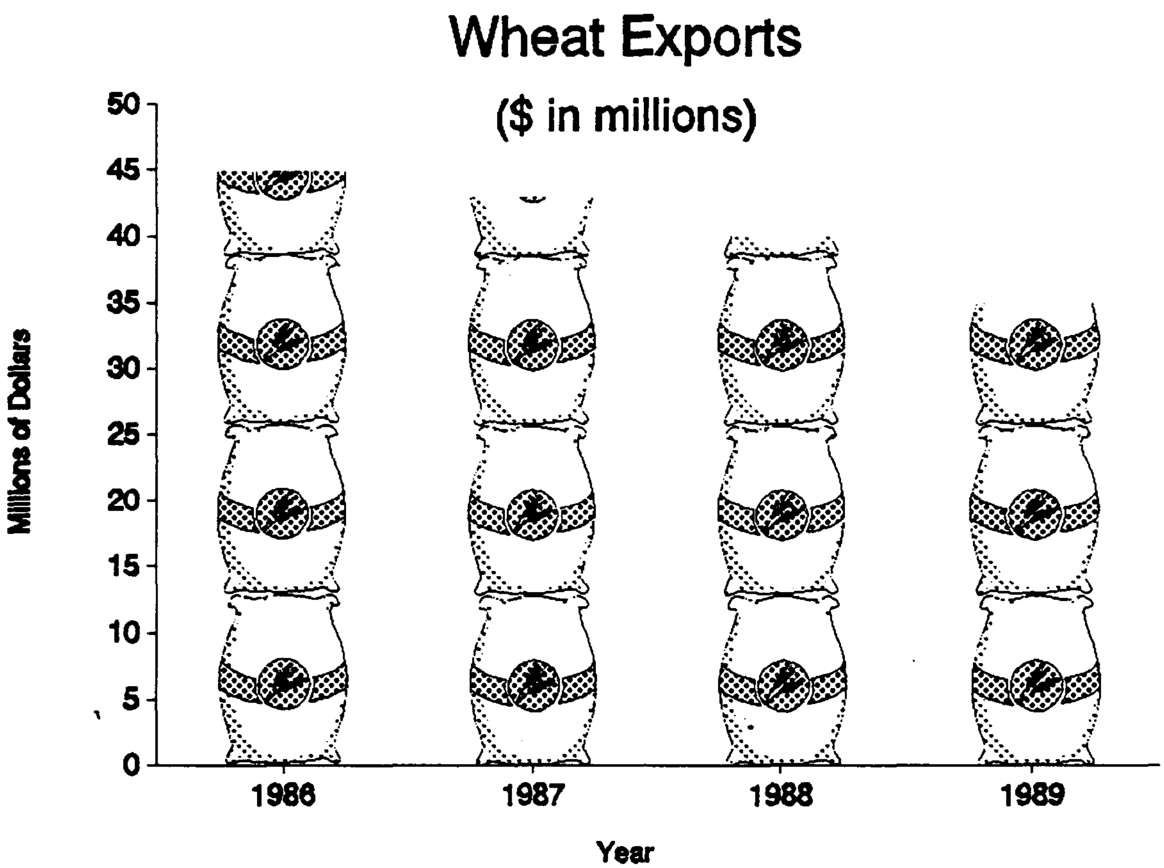
1 2 3 4 5 6 7 8 9

Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree



The trend in wheat exports has been

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Very Insignificant — Very Significant

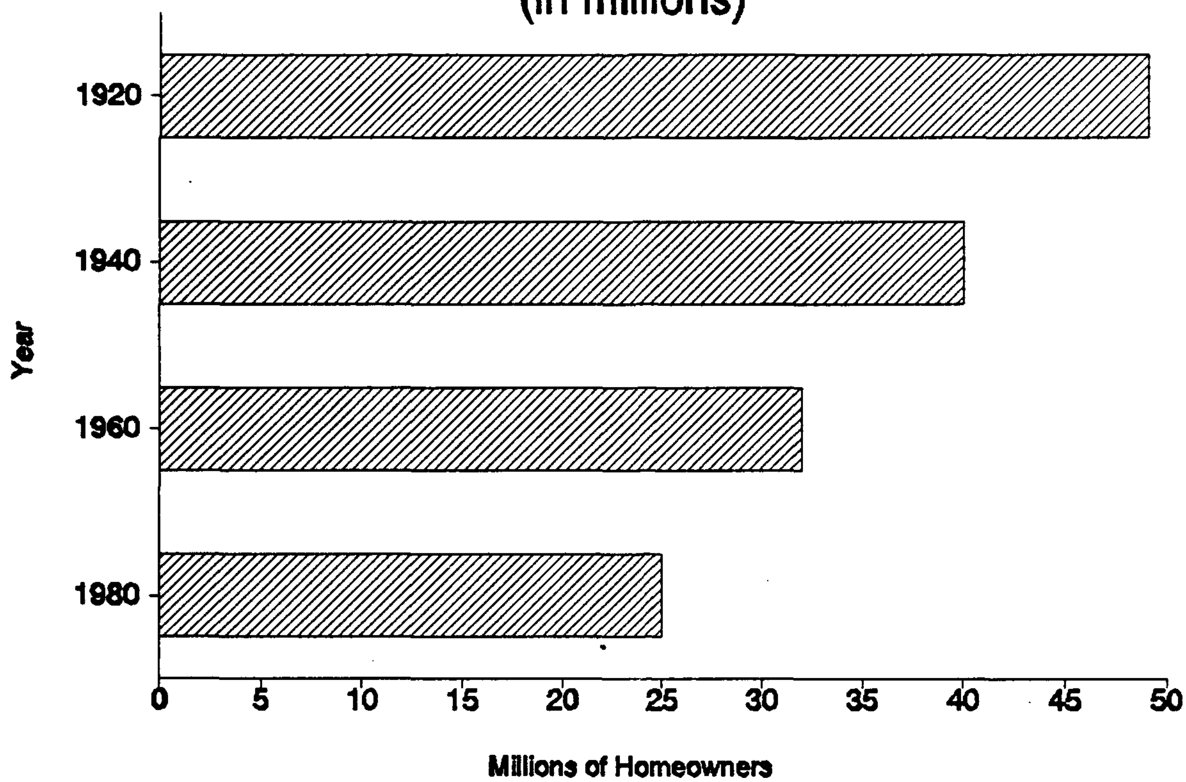
This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Strongly Disagree — Strongly Agree

Number of Homeowners
(in millions)



The trend in the number of homeowners has been

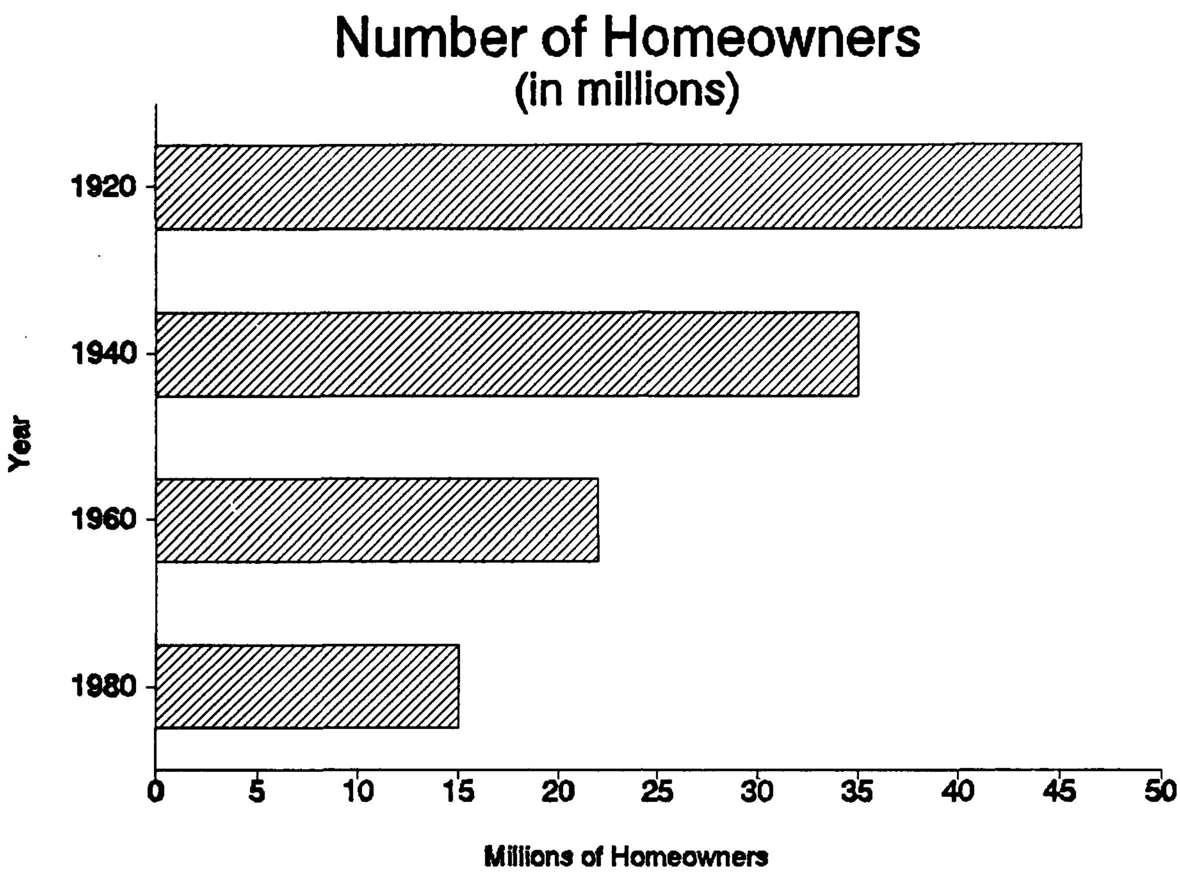
1 2 3 4 5 6 7 8 9

Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree



The trend in the number of homeowners has been

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

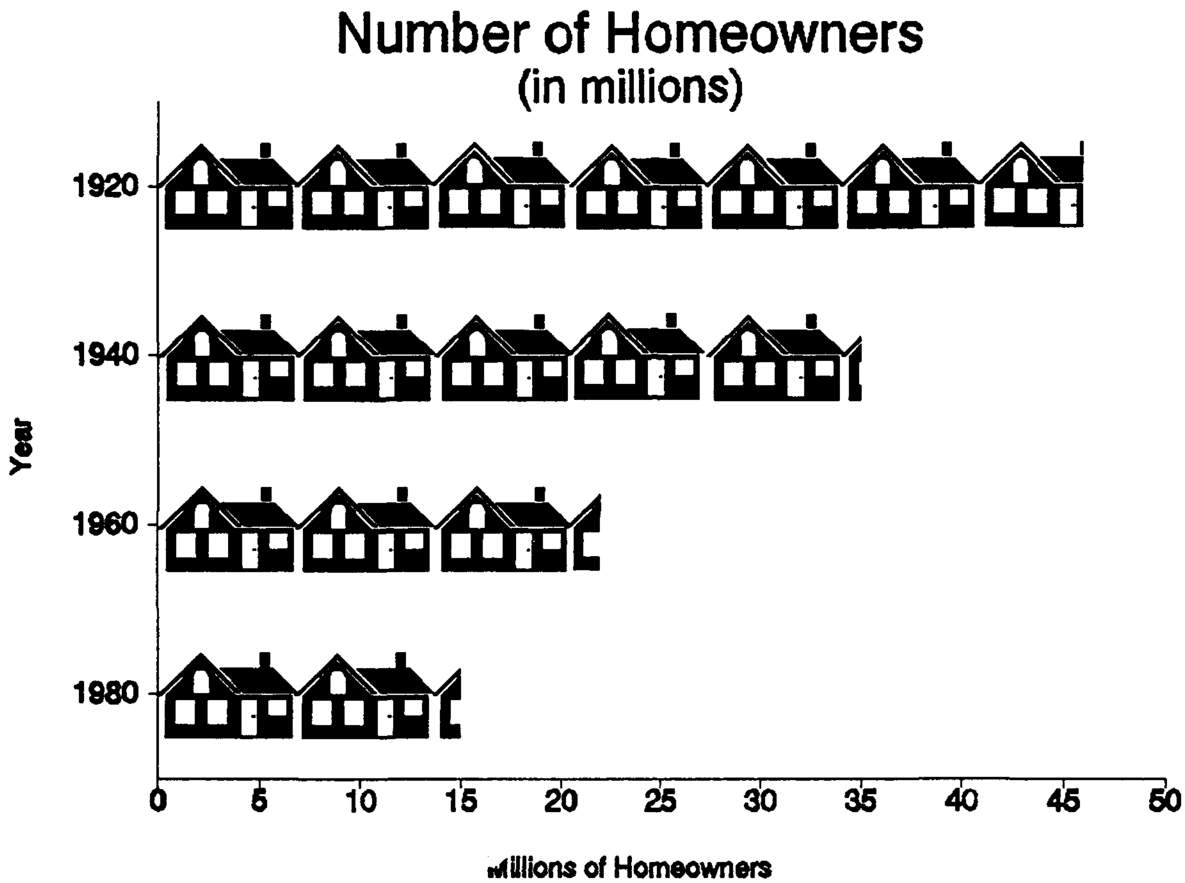
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

Strongly Disagree — Strongly Agree



The trend in the number of homeowners has been

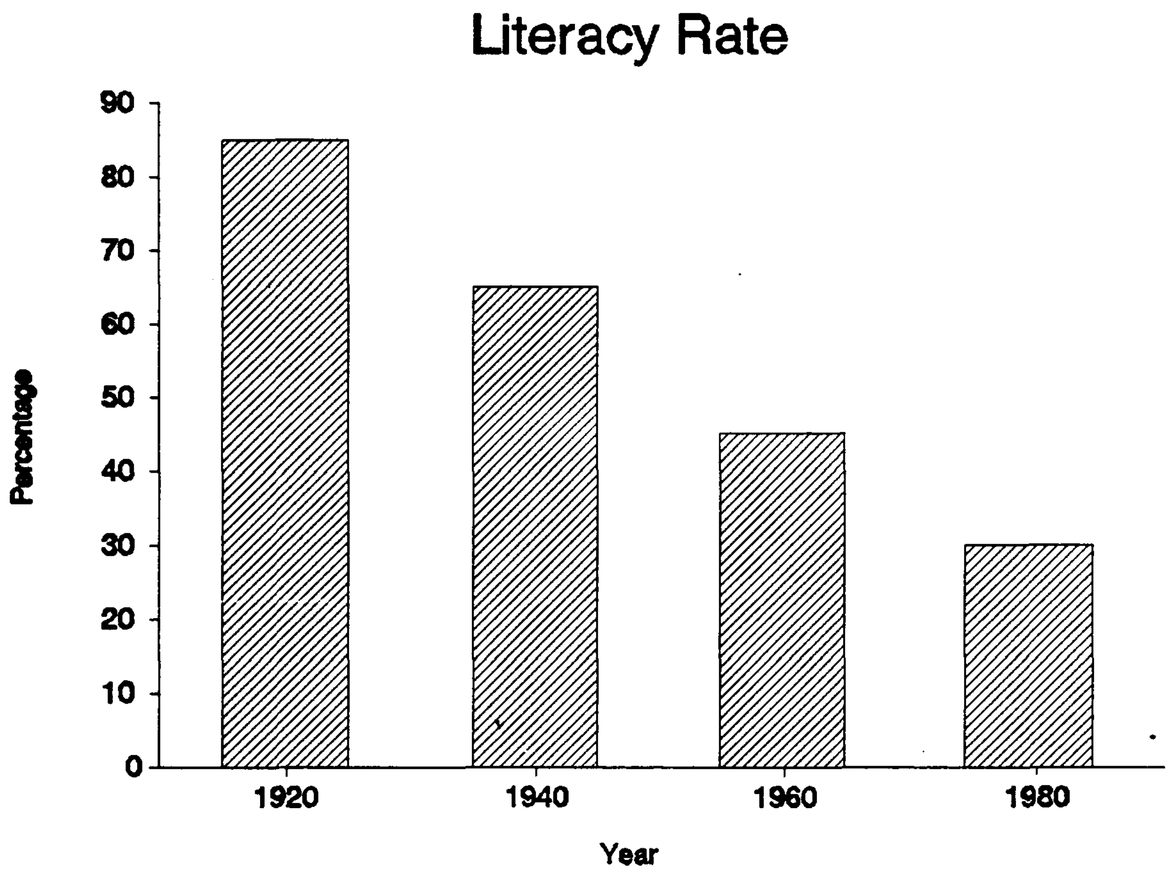
1 2 3 4 5 6 7 8 9

Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree



The trend in the literacy rate has been

1 2 3 4 5 6 7 8 9

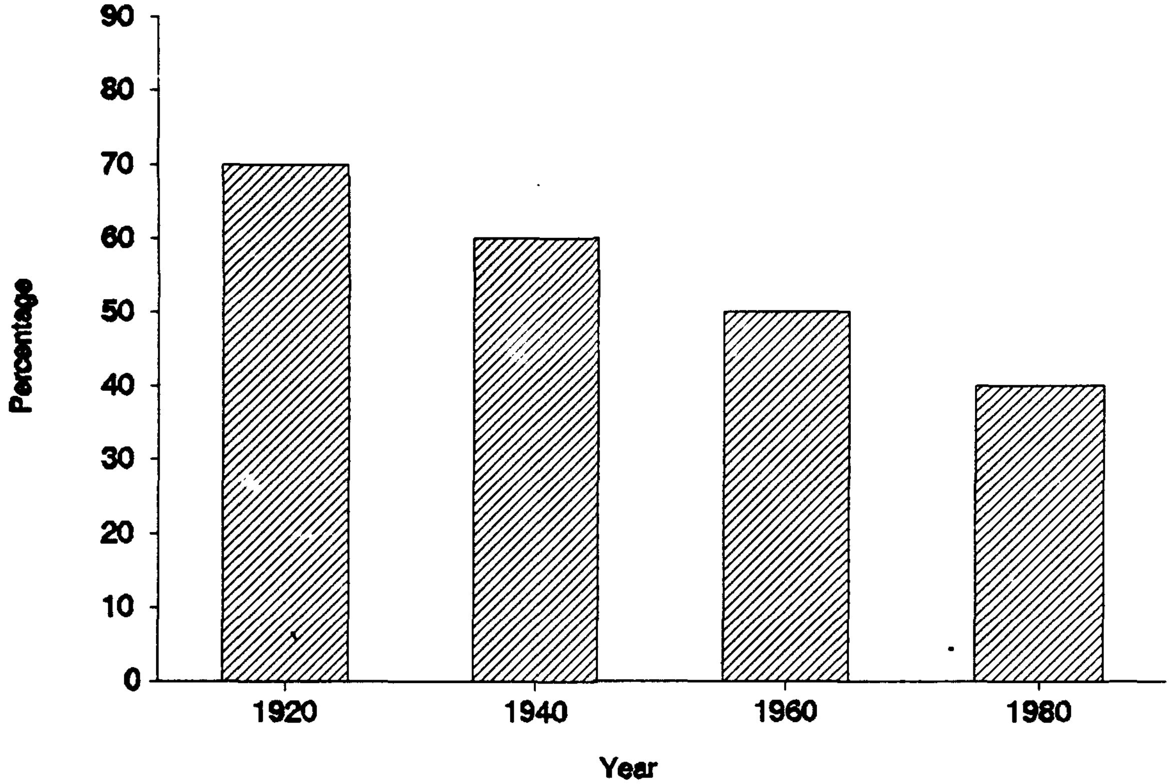
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree

Literacy Rate



The trend in the literacy rate has been

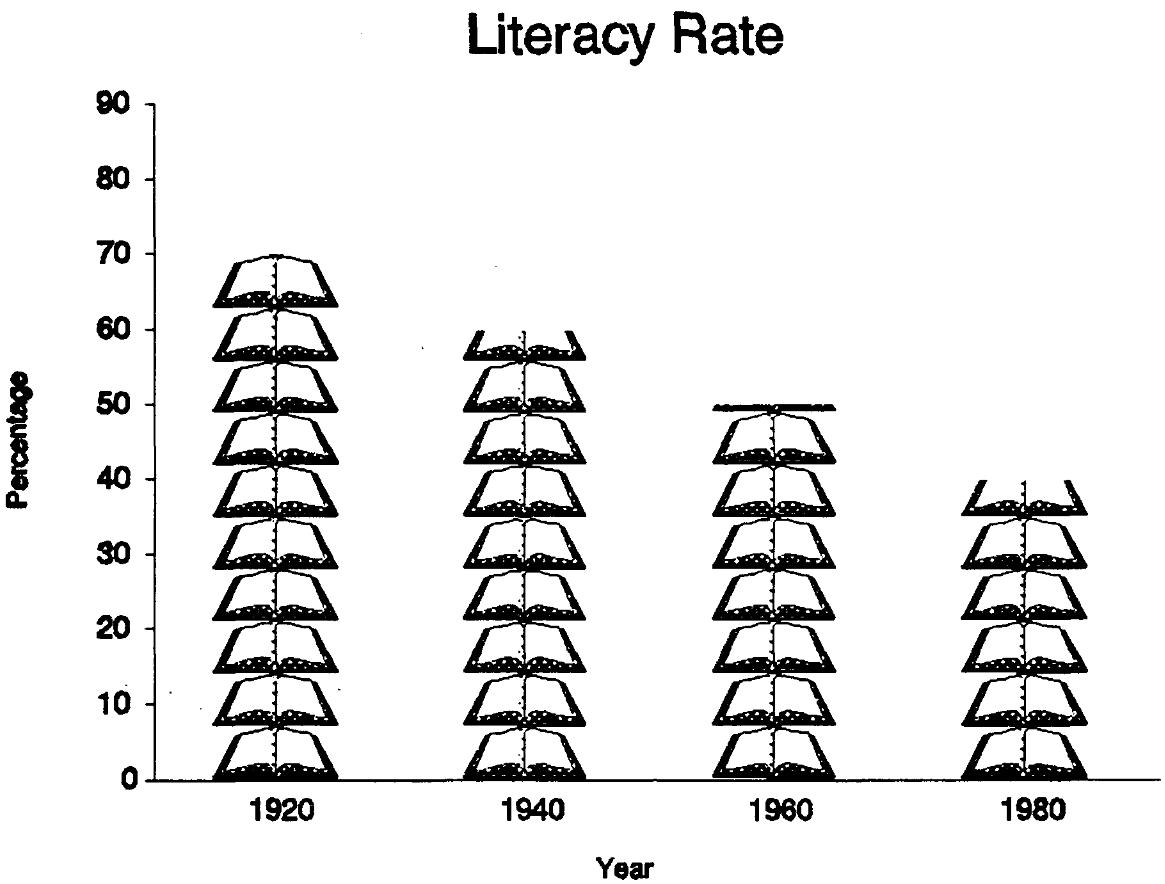
1 2 3 4 5 6 7 8 9

Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree



The trend in the literacy rate has been

1 2 3 4 5 6 7 8 9

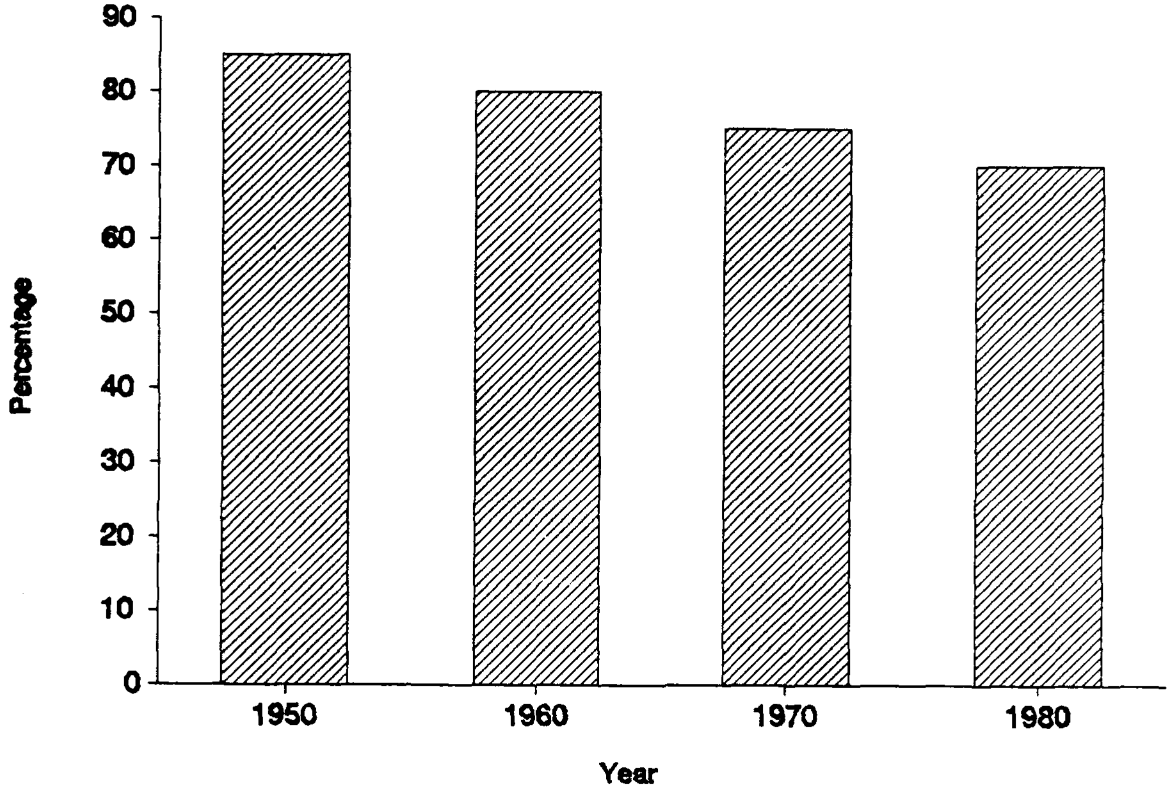
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree

Percentage of Tools Made in the US



The trend in US made tools has been

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

Very Insignificant — Very Significant

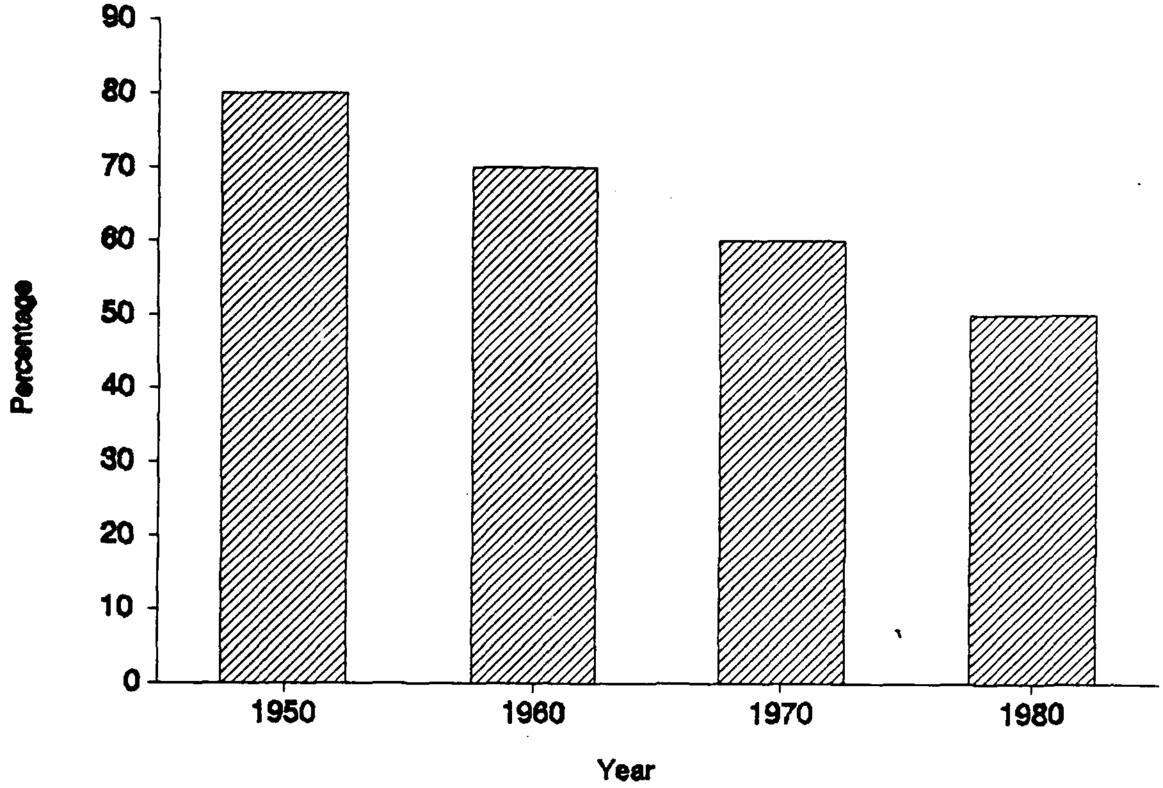
This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

Strongly Disagree — Strongly Agree

Percentage of Tools Made in the US



The trend in US made tools has been

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Very Insignificant — Very Significant

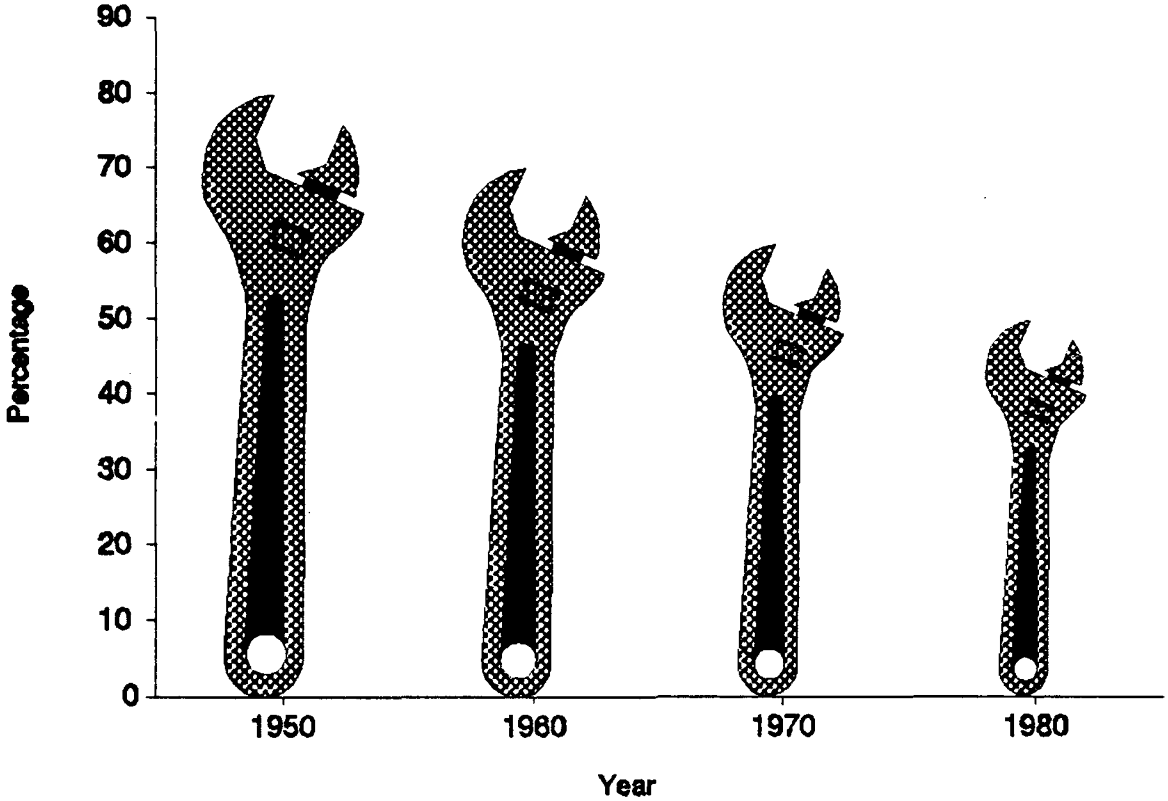
This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Strongly Disagree — Strongly Agree

Percentage of Tools Made in the US



The trend in US made tools has been

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

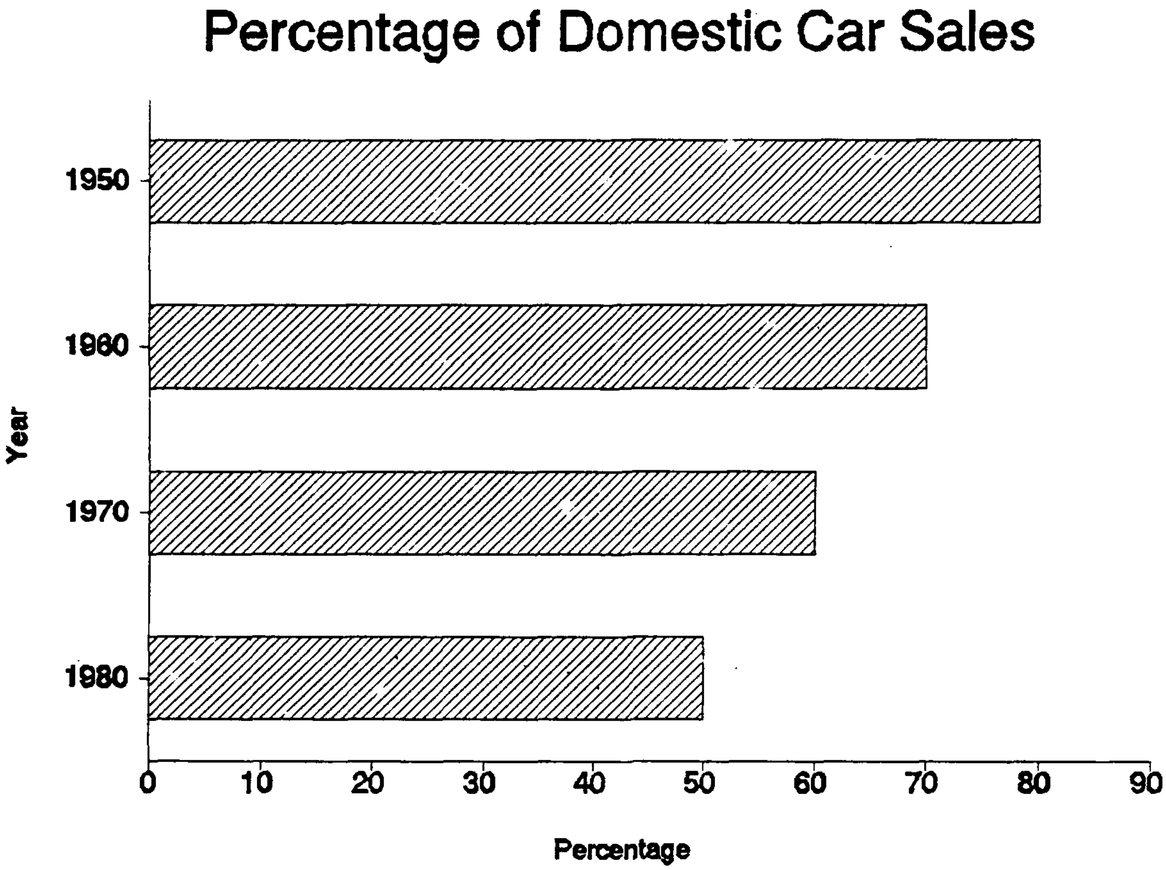
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|-------------------------|-------------------------|

Strongly Disagree — Strongly Agree



The trend in domestic car sales has been

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Very Insignificant — Very Significant

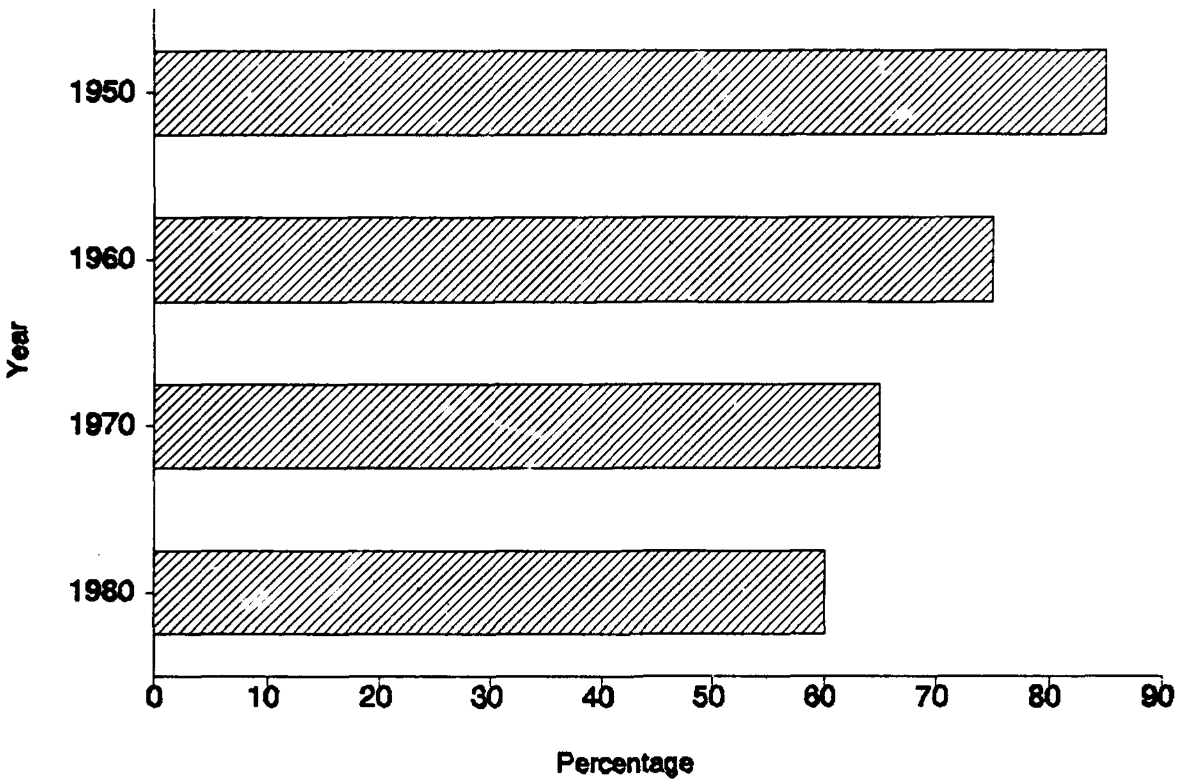
This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Strongly Disagree — Strongly Agree

Percentage of Domestic Car Sales



The trend in domestic car sales has been

1 2 3 4 5 6 7 8 9

|------------------------|-------------------------|

Very Insignificant — Very Significant

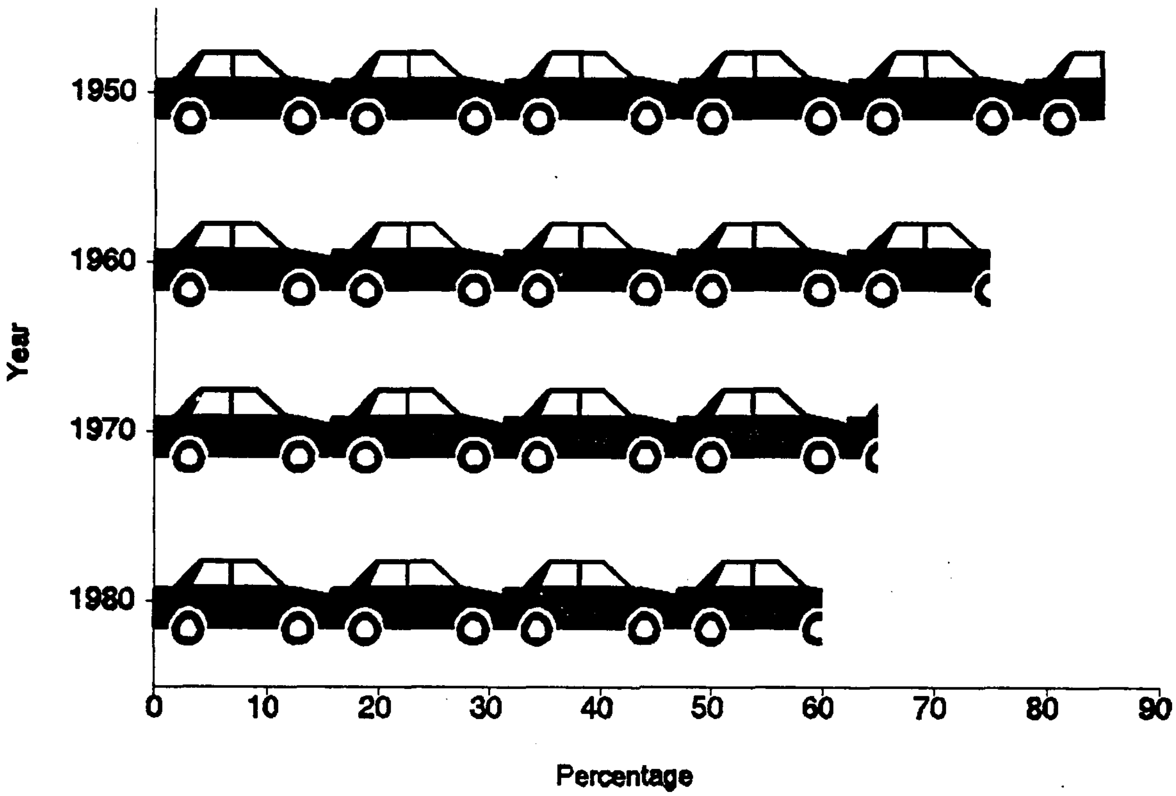
This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|------------------------|-------------------------|

Strongly Disagree — Strongly Agree

Percentage of Domestic Car Sales



The trend in domestic car sales has been

1 2 3 4 5 6 7 8 9

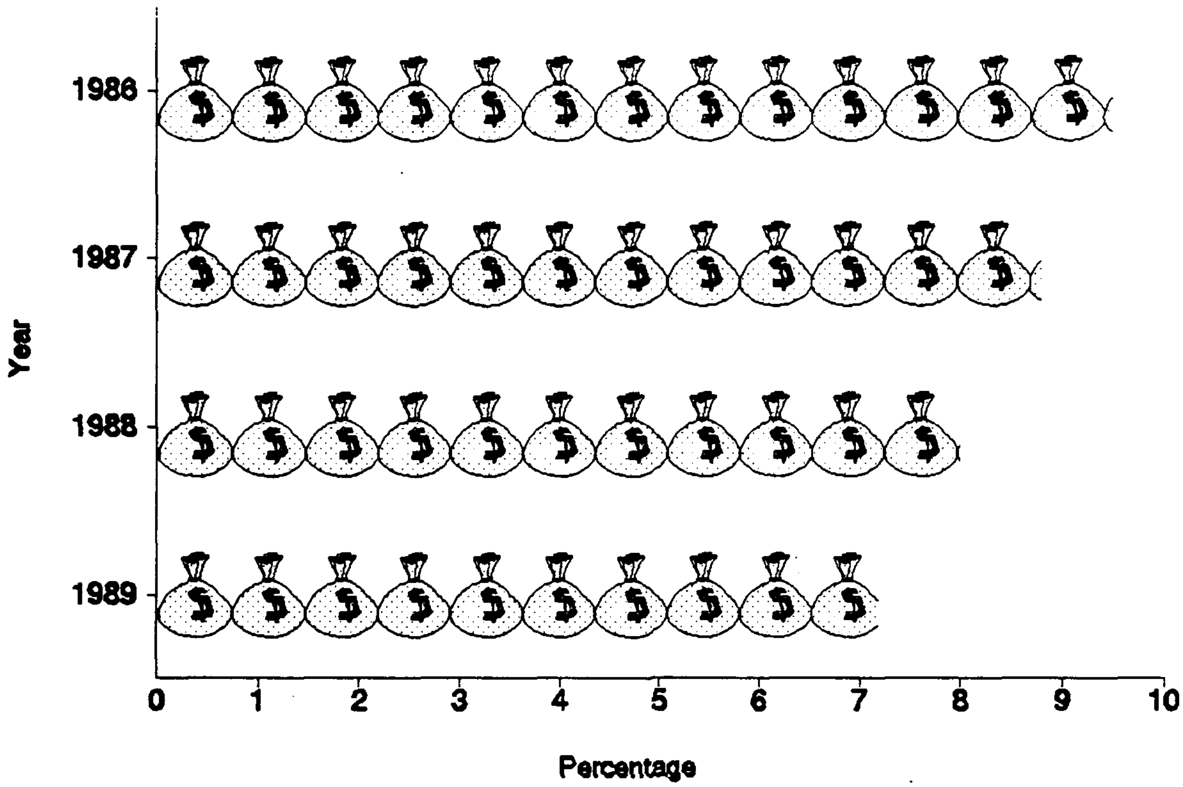
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree

Savings as a Percentage of Income



The trend in savings has been

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Very Insignificant — Very Significant

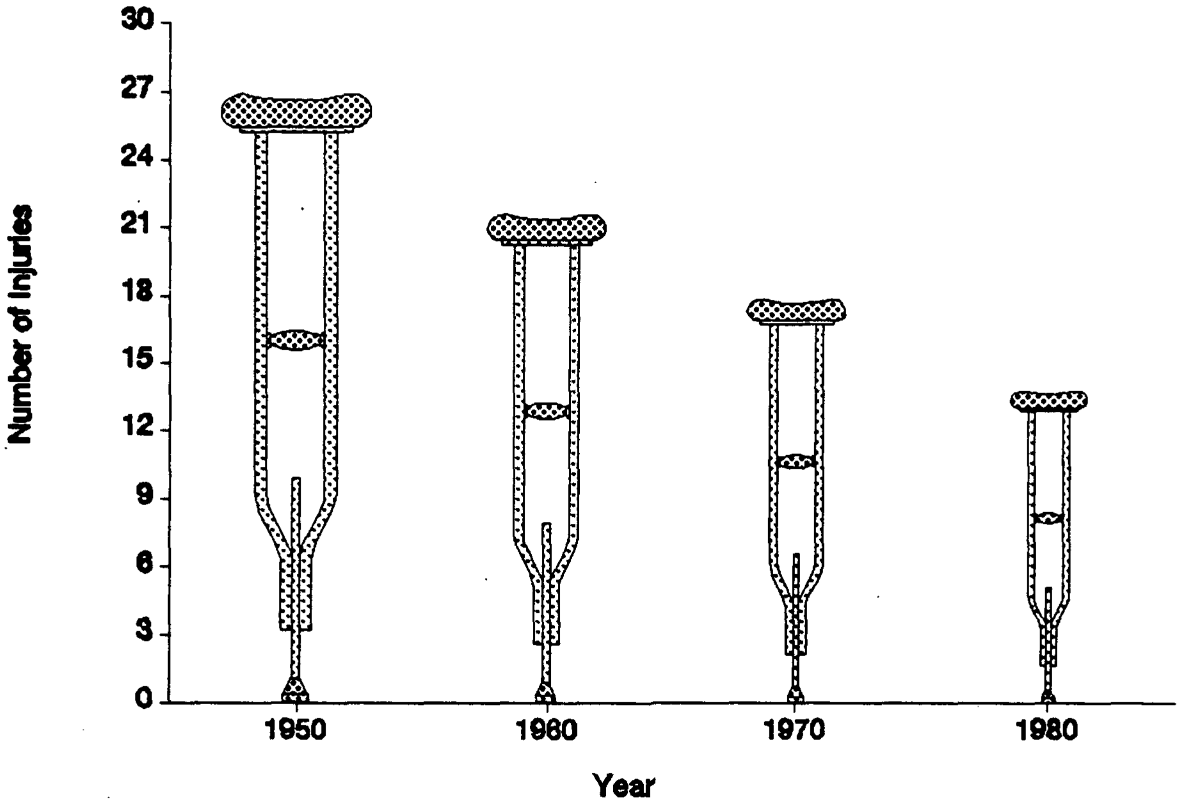
This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Strongly Disagree — Strongly Agree

Work Related Injuries

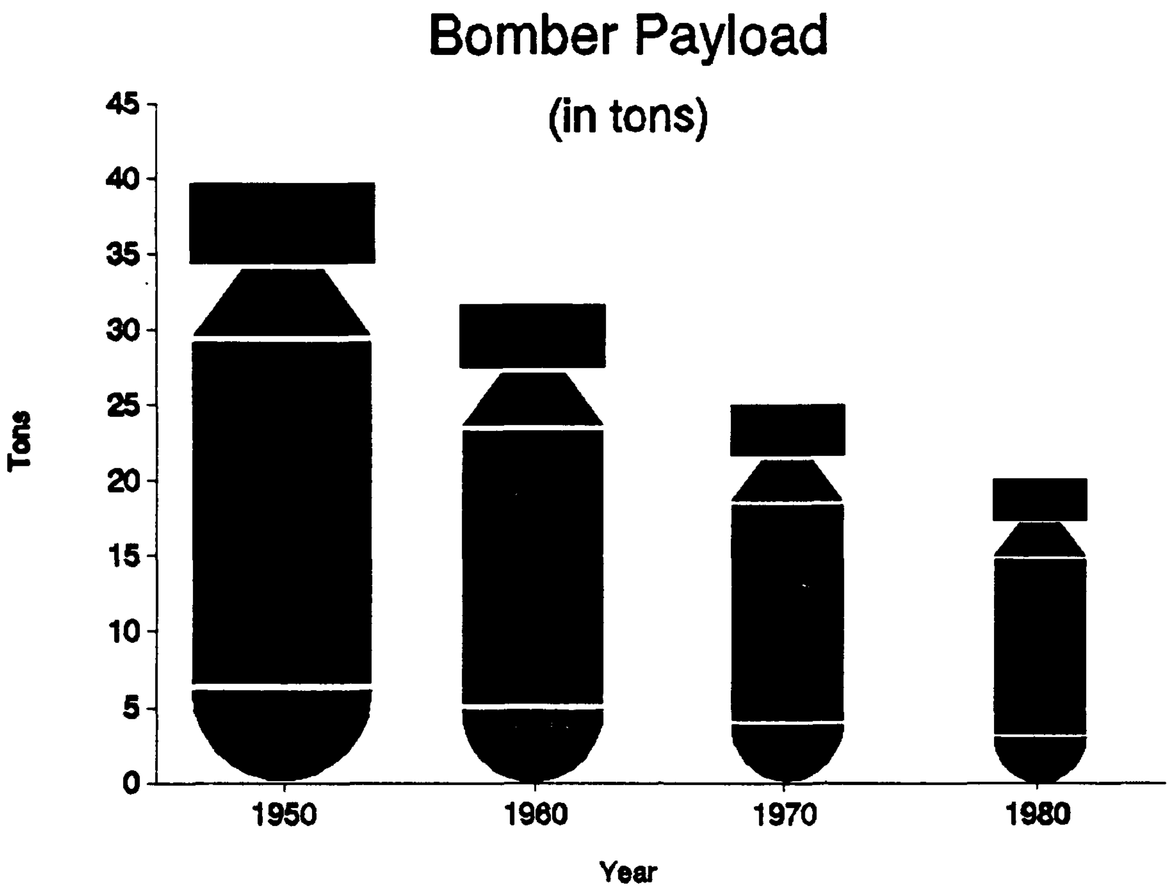


The trend in work related injuries has been

1	2	3	4	5	6	7	8	9
Very Insignificant								Very Significant

This is a good manner to present this data

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree



The trend in bomber payload has been

1 2 3 4 5 6 7 8 9

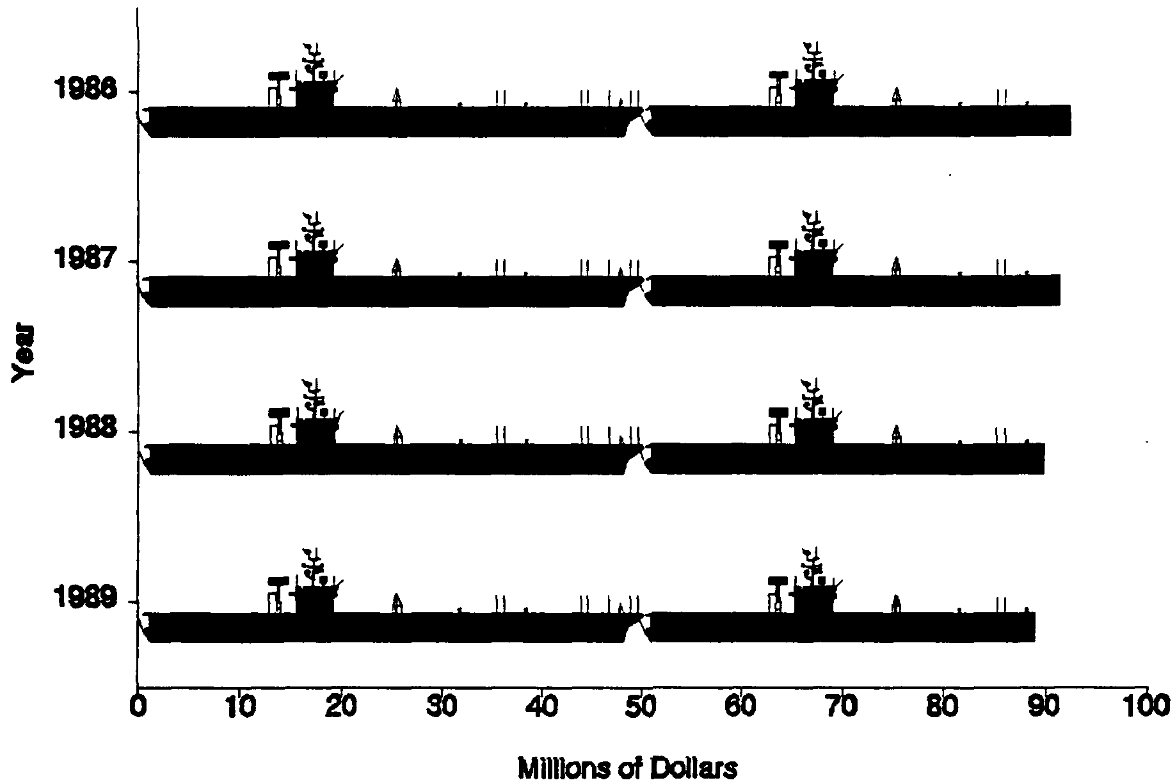
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree — Strongly Agree

US Car Exports



The trend in US car exports has been

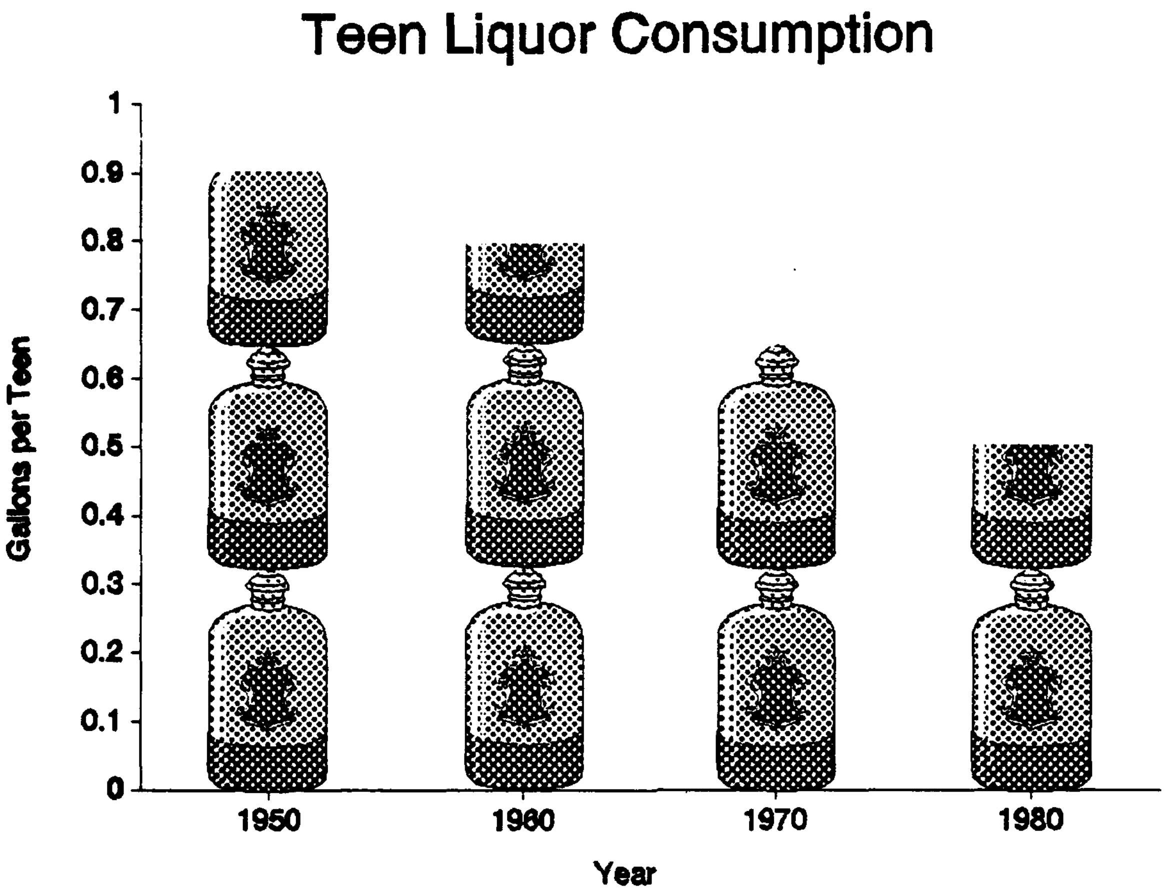
1 2 3 4 5 6 7 8 9

Very Insignificant ... Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree ... Strongly Agree



The trend in teen liquor consumption has been

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

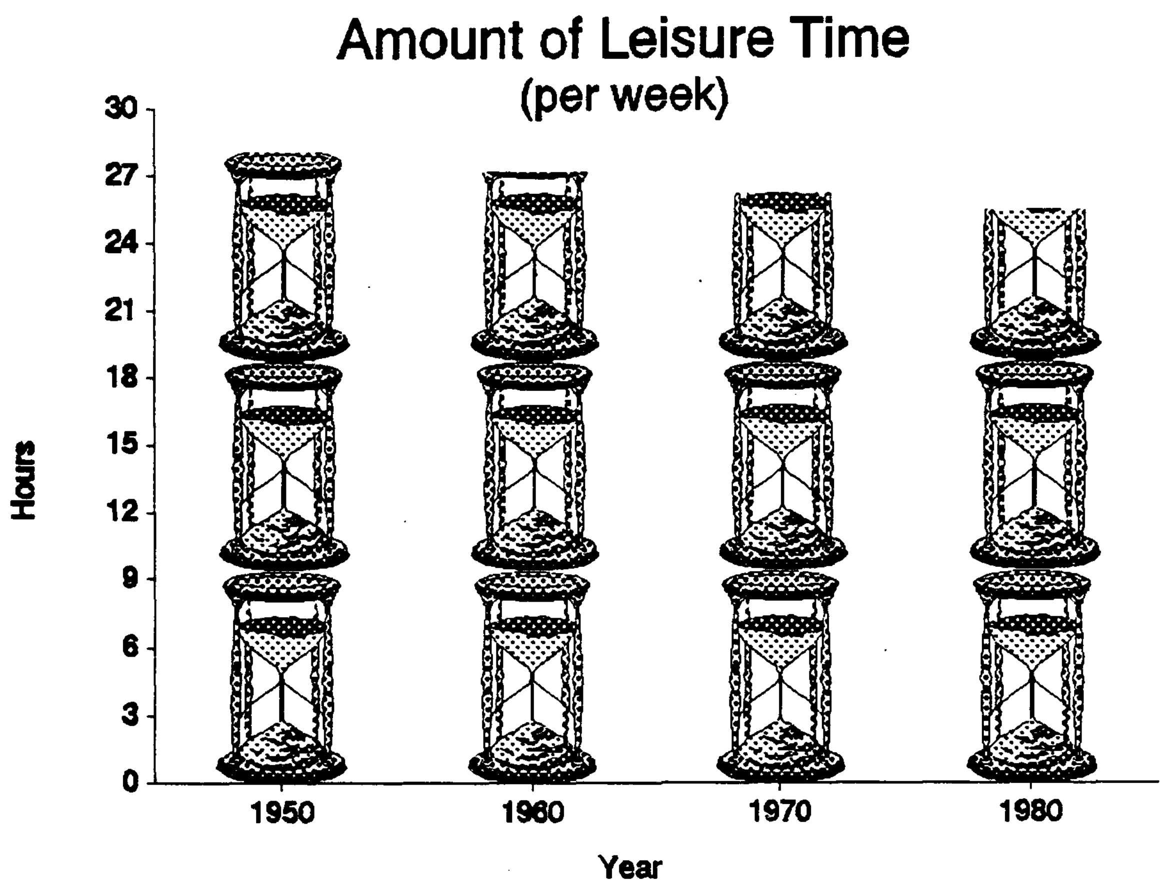
Very Insignificant — Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

|------------------------|------------------------|

Strongly Disagree — Strongly Agree



The trend in leisure time has been

1 2 3 4 5 6 7 8 9

Very Insignificant ... Very Significant

This is a good manner to present this data

1 2 3 4 5 6 7 8 9

Strongly Disagree ... Strongly Agree

The following information will be used to analyze the data collected in this experiment from different perspectives.

Check the appropriate answer.

1. Sex: Male____ Female____

2. Age: Under 18____ 18 - 25 ____ 26 - 35 ____ 36 - 45 ____ 46 - 55____ 56 - 65____ over 65____

3. Education Level:
   - High School ____
   - Some College ____
   - Associates Degree ____
   - Baccalaureate Degree ____
   - Some Graduate Courses ____
   - Masters Degree ____
   - Doctorate Degree ____

4. Rank/Grade:

E1 - E4	____	GS 1 - 5	____
E5 - E7	____	GS 5 - 8	____
E8 - E9	____	GS 9 - 12	____
O1 - O3	____	GS 13 - 15+	____
O4 - O5	____	GM 13 - 15+	____
O6	____	SES	____
O7 and above	____	Not applicable	____

5. Years of Service:

1 - 5	____	16 - 20	____	over 30	____
6 - 10	____	21 - 25	____	Not Applicable	____
11 - 15	____	26 - 30	____		

6. Supervisory Level:

I supervise no one	____	3rd Level supervisor	____
1st Level supervisor	____	4th Level or above	____
2nd Level supervisor	____		

7. How often do you see icons/pictures in graphics (i.e. magazines, newspapers, briefings)?

Never	____	Once a week	____
Once a year	____	Every other day	____
Once a month	____	Every Day	____
Twice a month	____		

8. How often do you use graphs in decision-making?

Never	____	Once a week	____
Once a year	____	Every other day	____
Once a month	____	Every Day	____
Twice a month	____		

9. How often do you construct graphs for presentations?

Never	____	Once a week	____
Once a year	____	Every other day	____
Once a month	____	Every Day	____
Twice a month	____		

10. Which graphic method do you prefer?

Horizontal Bar ____ Horizontal Icon Bar ____
Vertical Bar ____ Size Manipulated Icon ____
Vertical Icon Bar ____

11. Did any of the subjects in these graphs make you feel uneasy?

Yes ____ Which Ones: ____

No ____

12. Were there any charts that seemed ambiguous?

Yes ____ Which Ones: ____

No ____

13. Did you have any previous knowledge of this experiment or its subject?

Yes ____ No ____

14. Additional comments:

Appendix D. Raw Data

Control Group
Trend

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Sex
9	9	9	9	7	9	7	6	9	9	9	9	9	9	9	1	9	6	m
4	8	8	8	4	8	6	6	9	4	8	7	2	7	6	1	2	3	m
7	7	9	9	8	9	8	6	9	9	8	9	7	9	9	2	4	3	m
1	9	4	9	1	3	4	4	9	9	6	4	4	9	9	4	9	1	f
9	8.5	8	8	7	8	7	6	8	8	7	8	6	5	7	5	7	6	m
2	9	6	7	1	6	4	2	9	6	4	4	1	6	5	1	1	1	f
4	5	.	5	2	3	3	3	9	7	2	3	2	8	6	1	8	1	f
5	8	8	8	3	8	6	7	8	7	6	6	.	5	6	2	7	3	m
7	9	9	9	7	9	8	7	9	8	7	9	6	8	8	1	8	4	f
4	9	9	9	1	5	5	5	9	6	6	7	6	9	9	2	8	2	f
7	8	7	9	4	7	6	6	9	8	7	7	6	8	7	1	8	3	f
4	7	8	7	2	7	4	3	9	3	7	5	5	7	6	1	7	2	m
4	6	7	8	7	8	4	7	6	7	7	6	7	5	5	8	7	5	m
3	5	5	6	2	3	2	.	2	7	6	6	4	7	9	4	3	2	m
9	9	9	9	5	9	8	8	9	9	9	8	9	8	9	2	9	2	m
3	6	7	8	1	4	3	3	8	4	6	6	2	8	5	2	4	2	m
6	9	9	9	6	7	7	6	9	7	8	7	8	9	9	2	8	3	m
5	7	6	9	2	5	7	6	8	8	7	7	8	6	8	4	6	3	f
4	6	8	8	4	8	5	3	7	4	6	7	7	6	6	2	8	7	m
7	8	9	8	6	8	8	6	9	8	7	8	6	8	8	2	8	4	m
5	5	7	5	2	5	4	3	7	6	5	4	5	7	4	3	6	3	m
4	7	6	6	2	6	4	3	7	5	5	6	6	5	7	2	7	2	f
9	8	8	8	7	5	6	7	9	9	9	9	9	9	9	5	9	6	m
.	9	9	9	9	7	9	6	9	9	9	9	6	9	9	2	9	3	m
6	8	8	8	6	7	5	3	7	6	7	6	5	7	7	2	5	2	m
6	9	8	9	2	7	4	2	9	7	4	4	2	3	4	.	4	1	f
4	7	7	7	4	6	5	5	7	7	7	6	5	7	7	1	7	3	m
7	8	3	3	2	7	6	6	8	6	7	7	7	7	7	2	8	4	f
5	8	8	8	3	6	5	4	9	8	7	7	5	8	8	1	7	3	m
4	9	6	6	1	6	6	6	9	8	6	7	6	9	8	1	9	1	f
4	7	8	9	4	7	7	4	8	6	6	7	6	7	8	3	4	3	m
6	7	8	8	6	6	4	6	9	7	8	7	6	8	7	2	7	4	m
5	8	7	8	4	8	5	7	8	8	5	8	8	8	7	2	8	2	f
3	9	3	9	2	2	8	1	9	3	4	8	9	8	9	2	2	1	m
6	8	7	9	4	6	4	5	9	8	4	7	6	6	7	.	6	3	f
8	8	6	9	6	9	3	4	9	7	7	8	3	6	6	2	4	5	m
6	8	7	8	6	6	6	6	7	6	6	6	6	7	7	1	6	2	m
4	4	7	6	4	7	5	5	7	6	7	6	6	6	7	5	6	4	m
6	6	6	6	3	6	4	4	7	7	6	6	4	6	6	2	6	3	m
8	2	7	9	2	7	7	6	4	8	7	8	5	6	4	2	8	2	m
9	9	8	9	2	6	3	4	8	5	7	4	5	8	8	2	9	3	f
9	9	9	9	3	9	7	7	9	9	9	9	8	9	9	1	9	5	m
7	7	8	9	5	8	6	7	9	7	6	7	6	8	7	5	7	4	m
3	7	3	6	6	5	7	6	4	7	5	6	4	5	6	6	7	3	f
6	4	4	6	6	3	2	3	2	4	3	4	4	4	6	1	4	2	f
4	7	8	6	4	7	7	7	8	7	7	7	6	8	8	1	6	3	f
6	7	6	8	3	5	7	6	8	5	5	5	5	7	7	2	7	2	m
7	9	8	9	9	8	8	9	8	8	8	8	9	9	9	2	9	4	f
6	8	8	8	2	7	7	6	8	8	7	7	6	8	7	2	8	1	m

Experimental Group
Trend

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Sex
6	8	9	8	3	8	5	2	9	6	6	7	7	6	7	1	9	3	m
7	8	9	9	6	8	5	4	9	6	6	8	6	5	6	1	7	1	m
7	1	1	1	6	2	4	4	9	6	6	1	5	1	3	2	8	1	m
5	8	7	8	6	7	6	4	7	6	6	6	4	7	7	3	3	5	m
3	5	4	.	2	6	6	3	8	7	5	4	4	6	7	1	5	2	f
3	8	2	7	7	6	4	5	9	7	6	4	6	2	6	2	7	3	m
5	5	7	8	3	7	4	4	7	5	4	3	2	6	5	2	5	2	m
5	7	9	9	2	7	8	7	8	5	7	5	5	7	8	1	8	2	f
6	7	7	7	6	.	7	4	8	7	7	6	5	7	7	1	6	2	m
6	9	.	9	7	5	4	3	4	6	6	6	7	4	5	6	7	5	f
4	8	.	7	2	8	5	6	8	7	6	6	6	7	8	6	6	4	m
6	9	8	9	6	7	6	4	9	6	5	5	6	7	7	1	7	5	m
9	8	7	7	7	8	8	8	8	8	8	8	8	9	8	8	8	7	m
4	9	2	1	9	7	6	4	9	7	5	5	5	8	7	1	7	2	f
4	8	8	4	3	8	5	4	8	5	8	5	3	8	7	1	8	1	m
4	8	7	8	6	7	6	6	9	9	7	8	7	8	7	2	8	3	m
9	9	9	9	7	9	9	6	9	9	8	7	7	9	5	6	9	9	f
5	7	7	7	3	6	5	5	7	4	6	4	4	7	7	1	7	2	m
7	8	7	7	7	7	7	5	8	7	7	7	7	7	7	4	7	7	m
4	5	8	5	1	3	2	4	8	6	6	7	5	5	8	1	6	3	m
6	9	7	9	4	7	6	7	8	7	7	7	6	8	7	5	7	5	m
7	7	7	6	7	5	4	3	7	6	7	6	6	7	7	1	6	7	m
5	8	7	8	3	6	6	7	9	5	5	6	4	5	7	2	6	2	m
5	6	8	6	8	7	7	7	8	7	5	8	6	2	8	3	7	7	m
4	1	1	7	3	1	7	7	8	6	7	7	7	8	2	3	7	4	f
6	9	9	9	6	8	9	8	9	8	9	6	7	9	9	1	8	1	m
7	7	6	6	5	6	7	7	7	7	7	7	7	8	7	1	7	7	m
7	.	6	7	2	4	6	8	8	7	7	6	6	6	8	.	4	5	m
8	8	9	9	5	7	7	5	8	6	7	7	5	7	8	2	7	4	m
3	7	7	8	3	6	4	6	7	6	7	6	4	7	7	2	6	3	m
2	6	9	7	2	8	4	2	9	4	5	6	5	5	9	1	6	1	f
5	8	7	8	4	6	7	6	8	5	8	7	3	8	8	2	8	3	m
5	7	7	7	2	5	7	5	9	8	7	5	5	9	8	1	6	2	f
5	9	7	8	5	6	6	5	8	6	7	6	8	7	7	2	7	3	m
7	9	9	8	4	7	7	6	8	9	7	8	7	9	8	5	8	4	m
8	9	8	9	5	8	7	7	9	8	9	7	8	9	9	1	8	2	m
3	8	6	7	5	5	4	4	8	5	7	5	2	9	9	.	4	1	m
8	9	9	9	7	9	7	6	9	7	7	8	9	9	8	2	8	4	m
7	4	7	3	3	4	6	5	9	5	7	7	6	8	7	3	7	3	m
7	7	8	8	2	6	1	3	9	7	5	5	5	5	7	1	4	3	m
9	6	5	7	8	7	5	4	7	6	6	6	6	5	7	.	6	7	f
6	5	7	7	3	6	4	3	8	6	6	6	7	5	6	2	6	2	m
6	8	7	4	2	4	8	6	8	7	7	8	6	8	4	5	7	6	f
7	5	.	6	7	7	7	5	5	6	4	2	4	4	8	4	7	7	m
5	7	7	7	3	4	6	4	7	6	7	5	4	7	7	1	7	1	f
4	8	7	7	3	7	4	5	7	7	7	6	8	7	7	2	7	4	m
3	6	5	7	3	5	4	5	7	5	4	4	4	6	4	.	6	2	m
1	9	9	9	1	6	1	5	9	1	5	1	5	1	1	1	1	1	f
4	7	3	6	3	3	4	2	9	7	7	5	3	2	5	1	8	2	f
8	9	4	8	7	9	7	7	8	7	7	8	7	8	7	3	8	6	f

Control Group Preference																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Sex
9	9	9	9	7	9	9	9	9	9	9	9	9	4	9	1	6	3	m
7	8	5	7	7	7	5	5	7	7	7	7	5	5	4	3	.	5	m
7	8	8	8	5	9	7	5	9	8	8	7	7	8	8	2	8	5	m
9	9	1	.	8	3	9	9	9	9	8	9	9	9	6	1	3	1	f
.	5	3	7	3	5	7	6	8	8	7	5	6	3	7	2	7	4	m
4	4	4	4	3	4	4	3	3	4	4	3	1	3	4	3	2	1	f
3	6	.	4	4	.	2	2	.	.	3	.	5	6	.	5	.	2	f
7	7	8	8	2	7	7	3	7	8	5	5	.	2	2	7	2	4	m
9	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	f
5	7	8	9	6	6	6	6	8	6	6	7	6	8	9	3	7	9	f
9	8	8	8	8	8	8	8	8	8	8	8	6	8	8	6	8	5	f
8	9	3	9	8	3	8	8	2	7	8	2	8	8	8	3	7	8	m
8	5	6	7	7	8	4	7	6	7	7	6	6	5	5	6	7	5	m
5	6	6	5	2	4	6	.	5	6	6	5	4	7	7	3	5	2	m
9	9	6	2	5	6	6	8	8	9	9	6	9	9	9	8	9	2	m
7	7	5	8	8	6	7	4	2	7	8	1	1	1	2	1	2	2	m
.	8	8	8	8	8	8	8	8	8	8	7	4	9	9	3	6	2	m
8	8	9	9	4	7	6	8	9	9	7	8	6	4	7	2	3	4	f
4	7	6	6	6	6	4	4	6	4	5	7	8	6	6	1	3	4	m
7	7	6	7	6	7	7	6	8	7	6	8	6	8	8	4	7	4	m
5	3	5	5	5	5	5	5	5	5	5	4	4	3	3	1	4	3	m
6	7	5	6	7	6	6	6	7	6	6	2	2	2	2	5	5	7	f
9	8	5	8	9	4	9	9	5	9	9	5	5	5	9	5	9	7	m
.	8	7	9	6	5	6	6	8	8	8	7	4	8	9	2	6	3	m
8	7	5	7	6	5	7	5	5	6	6	5	5	8	7	2	6	6	m
6	4	7	7	7	7	7	3	4	6	6	3	1	6	4	3	3	2	f
5	7	5	7	6	4	6	6	5	7	6	4	6	7	4	1	5	4	m
7	8	4	4	8	6	7	7	8	7	7	7	7	7	7	7	7	7	f
5	3	2	7	7	2	5	7	2	3	7	2	2	6	7	2	6	2	m
9	9	1	6	9	3	9	6	2	8	6	2	2	9	9	2	9	8	f
4	4	.	7	5	6	6	5	6	6	5	5	2	2	7	2	2	1	m
7	7	3	8	4	5	7	6	7	6	6	6	3	8	8	3	7	2	m
4	7	7	8	4	8	5	6	8	8	5	8	7	8	7	5	8	7	f
9	9	1	9	9	2	9	9	1	9	6	1	9	9	9	1	8	9	m
3	6	5	5	3	5	3	5	5	5	3	5	5	5	6	1	5	5	f
9	8	1	8	6	3	6	6	4	8	8	6	2	4	1	4	3	2	m
6	5	2	5	5	2	5	5	2	5	5	2	5	7	7	3	7	7	m
5	6	4	6	6	2	4	3	2	2	4	4	3	3	4	2	3	2	m
4	6	4	6	3	4	4	4	4	6	4	4	3	5	6	6	6	3	m
7	3	8	5	4	2	8	8	4	2	8	6	3	9	8	1	7	6	m
7	8	4	9	7	3	8	6	4	8	8	3	5	8	8	1	9	6	f
9	9	1	9	9	1	7	4	1	8	9	1	2	4	9	1	6	1	m
8	7	6	6	7	6	4	6	6	4	6	6	6	6	6	2	8	3	m
6	7	7	2	6	3	7	5	3	7	7	2	3	6	6	4	3	2	f
5	5	4	5	6	6	7	7	5	7	6	6	4	6	6	1	5	4	f
8	.	8	8	5	8	6	6	5	7	5	7	3	4	5	3	5	3	f
7	5	6	2	7	5	7	4	7	3	3	4	1	7	3	2	3	4	m
7	8	2	9	9	2	8	8	3	8	8	3	9	8	3	2	9	8	f
5	8	3	8	5	2	7	6	4	7	5	5	3	7	7	2	2	4	m

Experimental Group
Preference

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Sex
8	8	9	8	8	8	8	3	6	6	5	4	5	7	7	4	4	2	m
7	8	8	9	6	8	6	7	8	7	7	8	3	4	5	1	7	3	m
.	.	9	9	7	9	1	1	.	4	1	1	4	1	1	1	1	1	m
6	8	5	7	6	7	4	4	8	4	8	5	4	7	6	3	3	4	m
7	5	7	.	8	8	6	7	8	7	7	6	6	7	2	9	5	6	f
5	7	5	7	7	5	4	4	3	5	4	5	3	4	3	3	4	3	m
7	5	4	6	4	6	5	5	5	4	3	2	4	5	4	2	4	3	m
9	9	9	9	9	9	6	5	7	6	4	4	3	7	5	6	6	9	f
8	7	3	7	7	.	2	2	2	4	2	2	2	2	2	2	2	2	m
7	.	.	9	7	6	4	.	4	6	6	6	4	.	5	7	7	7	f
7	8	.	7	4	4	8	8	9	6	6	9	8	8	6	7	8	9	m
6	8	7	8	7	6	4	3	5	5	3	5	4	6	5	3	4	3	m
4	6	5	5	5	6	5	7	8	8	5	7	8	9	8	3	5	4	m
6	8	4	8	9	6	6	5	9	7	5	6	6	3	6	6	7	7	f
5	7	8	2	5	6	4	5	5	5	4	5	4	5	6	5	5	5	m
6	7	7	9	7	7	3	3	8	9	4	6	4	7	9	3	7	2	m
9	9	9	9	9	9	9	6	9	9	8	7	7	9	9	6	9	9	f
6	7	4	6	6	4	5	5	5	4	5	5	4	5	5	2	5	5	m
7	7	7	6	3	7	4	5	6	5	3	5	4	4	6	3	5	6	m
1.5	5	7	3	3	5	4	3	4	3	3	5	3	2	5	1	2	1	m
5	7	4	7	5	5	5	7	7	5	6	6	7	4	6	2	6	4	m
7	3	2	4	4	1	5	1	8	5	4	6	4	1	7	1	1	1	m
7	8	4	8	7	3	7	7	4	8		2	3	3	6	1	5	5	m
5	4	9	6	8	8	2	4	8	9	5	8	6	4	6	3	6	7	m
6	6	7	6	4	4	6	6	7	6	6	4	4	6	5	3	5	4	f
6	9	9	9	6	9	7	7	9	8	9	5	6	9	8	9	7	8	m
7	7	3	7	7	4	6	6	4	6	6	6	4	7	6	2	7	6	m
7	.	4	7	7	4	5	4	8	4	6	6	5	2	2	.	2	3	m
7	7	8	8	7	4	5	4	8	4	5	6	5	7	8	3	5	6	m
8	8	5	7	7	7	6	6	6	7	7	6	3	7	8	3	6	4	m
7	9	9	7	7	4	4	5	9	4	5	6	5	6	9	1	6	4	f
6	8	6	8	4	6	5	3	2	3	7	5	3	6	8	2	4	2	m
5	7	8	7	8	5	8	7	9	8	8	9	8	9	8	1	8	2	f
7	7	7	7	7	7	6	4	8	6	5	4	6	8	7	5	6	4	m
7	8	8	8	5	8	4	5	7	4	6	5	5	7	8	1	3	3	m
8	8	4	8	4	3	4	3	8	5	7	5	3	8	9	1	4	1	m
6	7	1	6	7	3	5	6	3	5	4	6	4	5	4	1	3	6	m
7	7	7	7	6	7	7	4	7	7	7	7	7	7	7	5	6	5	m
8	7	7	7	7	7	7	7	8	6	7	7	7	7	8	5	7	6	m
7	8	8	8	2	7	1	5	7	1	1	5	5	1	3	1	4	4	m
8	7	8	8	8	6	5	6	7	6	6	6	6	5	6	3	6	3	f
6	4	6	7	3	6	4	6	7	6	3	7	6	5	6	1	6	7	m
7	6	6	7	3	6	6	6	7	8	6	7	7	8	7	5	7	3	f
3	5	.	6	3	4	3	4	3	6	4	7	7	3	7	7	4	3	m
4	7	4	5	6	4	4	3	6	3	7	4	5	7	6	2	6	3	f
7	7	7	7	7	7	3	4	6	4	6	5	5	6	6	2	4	3	m
5	5	3	5	6	3	2	3	1	4	3	1	1	2	3	.	3	3	m
9	9	1	1	9	6	1	9	9	5	1	5	1	7	9	1	9	1	f
4	5	9	5	6	6	4	3	6	4	3	6	5	2	6	1	8	2	f
7	8	7	9	.	8	4	5	9	8	8	8	4	7	6	1	7	3	f

Appendix E. "Diff" Values Used in the Analysis

Control Group
Trend

Obs	H_o1	1/7	5/11	H_o2	3/9	6/12	H_o3	2/8	4/10
1	0	-2	2	0	0	0	-3	-3	0
2	6	2	4	0	1	-1	-6	-2	-4
3	1	1	0	0	0	0	-1	-1	0
4	8	3	5	6	5	1	-5	-5	0
5	-2	-2	0	0	0	0	-3	-3	0
6	5	2	3	1	3	-2	-8	-7	-1
7	-1	-1	0	.	.	0	0	-2	2
8	4	1	3	-2	0	-2	-2	-1	-1
9	1	1	0	0	0	0	-3	-2	-1
10	6	1	5	2	0	2	-7	-4	-3
11	2	-1	3	2	2	0	-3	-2	-1
12	5	0	5	-1	1	-2	-8	-4	-4
13	0	0	0	-3	-1	-2	0	1	-1
14	3	-1	4	0	-3	3	.	.	1
15	3	-1	4	-1	0	-1	-1	-1	0
16	5	0	5	3	1	2	-7	-3	-4
17	3	1	2	0	0	0	-5	-3	-2
18	7	2	5	4	2	2	-2	-1	-1
19	3	1	2	-2	-1	-1	-7	-3	-4
20	2	1	1	0	0	0	-2	-2	0
21	2	-1	3	-1	0	-1	-1	-2	1
22	3	0	3	1	1	0	-5	-4	-1
23	-1	-3	2	5	1	4	0	-1	1
24	.	.	0	2	0	2	-3	-3	0
25	0	-1	1	-2	-1	-1	-7	-5	-2
26	0	-2	2	-2	1	-3	-9	-7	-2
27	4	1	3	0	0	0	-2	-2	0
28	4	-1	5	5	5	0	1	-2	3
29	4	0	4	2	1	1	-4	-4	0
30	7	2	5	4	3	1	-1	-3	2
31	5	3	2	0	0	0	-6	-3	-3
32	0	-2	2	2	1	1	-2	-1	-1
33	1	0	1	1	1	0	-1	-1	0
34	7	5	2	12	6	6	-14	-8	-6
35	-2	-2	0	3	2	1	-4	-3	-1
36	-4	-5	1	2	3	-1	-6	-4	-2
37	0	0	0	0	0	0	-4	-2	-2
38	4	1	3	-1	0	-1	1	1	0
39	1	-2	3	1	1	0	-1	-2	1
40	4	-1	5	-2	-3	1	3	4	-1
41	-1	-6	5	-2	0	-2	-9	-5	-4
42	4	-2	6	0	0	0	-2	-2	0
43	0	-1	1	0	1	-1	-2	0	-2
44	3	4	-1	2	1	1	0	-1	1
45	-7	-4	-3	-1	-2	1	-3	-1	-2
46	6	3	3	0	0	0	1	0	1
47	3	1	2	2	2	0	-4	-1	-3
48	0	1	-1	0	0	0	-1	0	-1
49	6	1	5	0	0	0	-2	-2	0

Experimental Group
Trend

Obs	H_O1	1/7	5/11	H_O2	3/9	6/12	H_O3	2/8	4/10
51	2	-1	3	-1	0	-1	-8	-6	-2
52	-2	-2	0	0	0	0	-7	-4	-3
53	-3	-3	0	7	8	-1	8	3	5
54	1	1	0	-1	0	-1	-6	-4	-2
55	6	3	3	1	2	-1	.	-2	.
56	0	1	-1	5	7	-2	-3	-3	0
57	0	-1	1	-4	0	-4	-4	-1	-3
58	8	3	5	-3	-1	-2	-4	0	-4
59	2	1	1	.	0	.	-3	-3	0
60	-3	-2	-1	.	.	1	-9	-6	-3
61	5	1	4	.	.	-2	-2	-2	0
62	-1	0	-1	-1	1	-2	-8	-5	-3
63	0	-1	1	1	1	0	1	0	1
64	-2	2	-4	5	7	-2	1	-5	6
65	6	1	5	-3	0	-3	-3	-4	1
66	3	2	1	3	2	1	-1	-2	1
67	1	0	1	-2	0	-2	-3	-3	0
68	3	0	3	-2	0	-2	-5	-2	-3
69	0	0	0	1	1	0	-3	-3	0
70	3	-2	5	4	0	4	0	-1	1
71	3	0	3	1	1	0	-4	-2	-2
72	-3	-3	0	1	0	1	-4	-4	0
73	3	1	2	2	2	0	-4	-1	-3
74	-1	2	-3	1	0	1	2	1	1
75	7	3	4	13	7	6	5	6	-1
76	6	3	3	-2	0	-2	-2	-1	-1
77	2	0	2	2	1	1	1	0	1
78	4	-1	5	3	0	3	.	.	0
79	1	-1	2	-1	-1	0	-6	-3	-3
80	5	1	4	0	0	0	-3	-1	-2
81	5	2	3	-2	0	-2	-7	-4	-3
82	6	2	4	2	1	1	-5	-2	-3
83	7	2	5	2	2	0	-1	-2	1
84	3	1	2	1	1	0	-6	-4	-2
85	3	0	3	0	-1	1	-2	-3	1
86	3	-1	4	0	1	-1	-3	-2	-1
87	3	1	2	2	2	0	-6	-4	-2
88	-1	-1	0	-1	0	-1	-5	-3	-2
89	3	-1	4	5	2	3	3	1	2
90	-3	-6	3	0	1	-1	-5	-4	-1
91	-6	-4	-2	1	2	-1	-3	-2	-1
92	1	-2	3	1	1	0	-3	-2	-1
93	7	2	5	5	1	4	1	-2	3
94	-3	0	-3	.	.	-3	0	0	0
95	5	1	4	1	0	1	-4	-3	-1
96	4	0	4	-1	0	-1	-3	-3	0
97	2	1	1	1	2	-1	-3	-1	-2
98	4	0	4	-5	0	-5	-12	-4	-8
99	4	0	4	8	6	2	-4	-5	1
100	-1	-1	0	3	4	-1	-3	-2	-1

Control Group
Preference

Obs	H_o1	1/7	5/11	H_o2	3/9	6/12	H_o3	2/8	4/10
1	2	0	2	0	0	0	0	0	0
2	-2	-2	0	2	0	2	-3	-3	0
3	3	0	3	-2	1	-3	-3	-3	0
4	0	0	0	14	6	8	.	0	.
5	.	.	4	5	0	5	2	1	1
6	1	0	1	-2	-1	-1	-1	-1	0
7	-2	-1	-1	.	.	.	.	-4	.
8	3	0	3	-3	-2	-1	-4	-4	0
9	0	0	0	1	0	1	1	1	0
10	1	1	0	1	0	1	-4	-1	-3
11	-1	-1	0	0	0	0	0	0	0
12	0	0	0	-2	-1	-1	-3	-1	-2
13	-4	-4	0	-2	-2	0	2	2	0
14	5	1	4	0	1	-1	.	.	1
15	1	-3	4	2	0	2	6	-1	7
16	0	0	0	-8	-5	-3	-4	-3	-1
17	.	.	0	-1	-1	0	0	0	0
18	1	-2	3	1	1	0	0	0	0
19	-1	0	-1	1	1	0	-5	-3	-2
20	0	0	0	3	1	2	-1	-1	0
21	0	0	0	-1	-1	0	2	2	0
22	-1	0	-1	-2	-4	2	-1	-1	0
23	0	0	0	1	1	0	2	1	1
25	-1	-1	2	3	2	1	-3	-2	-1
24	.	.	0	0	0	0	-3	-2	-1
26	0	1	-1	-2	1	-3	-2	-1	-1
27	1	1	0	0	0	0	-1	-1	0
28	-1	0	-1	5	1	4	2	-1	3
29	0	0	0	0	0	0	0	4	-4
30	-3	0	-3	0	-1	1	-1	-3	2
31	2	2	0	.	-1	.	0	1	-1
32	2	0	2	5	1	4	-3	-1	-2
33	2	1	1	1	0	1	-1	-1	0
34	-3	0	-3	-1	-1	0	0	0	0
35	0	0	0	0	0	0	-1	-1	0
36	-1	-3	2	6	3	3	-2	-2	0
37	-1	-1	0	0	0	0	0	0	0
38	-3	-1	-2	0	2	-2	-7	-3	-4
39	1	0	1	0	0	0	-2	-2	0
40	5	1	4	0	4	-4	2	5	-3
41	2	1	1	0	0	0	-3	-2	-1
42	-2	-2	0	0	0	0	-6	-5	-1
43	-5	-4	-1	0	0	0	-3	-1	-2
44	2	1	1	-5	-1	-4	3	-2	5
45	2	2	0	1	0	1	4	2	2
46	-2	-2	0	-4	-1	-3	.	.	-1
47	-4	0	-4	0	-1	1	0	-1	1
48	0	1	-1	2	1	1	-1	0	-1
49	2	2	0	4	3	1	-3	-2	-1

Experimental Group
Preference

Obs	H_O1	1/7	5/11	H_O2	3/9	6/12	H_O3	2/8	4/10
51	-3	0	-3	-7	-4	-3	-7	-5	-2
52	0	-1	1	0	0	0	-3	-1	-2
53	.	.	-6	.	-8	.	.	.	-5
54	0	-2	2	1	-2	3	-7	-4	-3
55	-2	-1	-1	-1	-2	1	.	2	.
56	-4	-1	-3	-2	0	-2	-5	-3	-2
57	-4	-2	-2	-2	-3	1	-2	0	-2
58	-9	-4	-5	-7	-5	-2	-7	-4	-3
59	-11	-6	-5	.	.	-1	-8	-5	-3
60	-4	-3	-1	.	0	.	.	.	-3
61	3	1	2	.	5	.	-1	0	-1
62	-6	-2	-4	-3	-1	-2	-8	-5	-3
63	1	1	0	4	1	3	4	1	3
64	-4	0	-4	5	0	5	-4	-3	-1
65	-2	-1	-1	-4	-1	-3	1	-2	3
66	-6	-3	-3	0	-1	1	-4	-4	0
67	-1	0	-1	-2	-2	0	-3	-3	0
68	-2	-1	-1	2	1	1	-4	-2	-2
69	-3	-3	0	-3	-2	-1	-3	-2	-1
70	2.5	2.5	0	-3	0	-3	-2	-2	0
71	1	0	1	4	1	3	-2	0	-2
72	-2	-2	0	11	5	6	-1	-2	1
73	-2	0	-2	-1	-1	0	-1	-1	0
74	-6	-3	-3	-1	0	-1	3	0	3
75	2	0	2	0	0	0	0	0	0
76	4	1	3	-4	-4	0	-3	-2	-1
77	-2	-1	-1	3	2	1	-2	-1	-1
78	-8	-3	-5	3	0	3	.	.	-3
79	-3	-2	-1	2	2	0	-7	-3	-4
80	-2	-2	0	0	-1	1	-2	-2	0
81	-5	-3	-2	-2	-2	0	-7	-4	-3
82	2	-1	3	-5	-1	-4	-10	-5	-5
83	3	3	0	5	4	1	1	0	1
84	-3	-1	-2	-2	-3	1	-4	-3	-1
85	-2	-3	1	-4	-3	-1	-7	-3	-4
86	-1	-4	3	6	2	4	-8	-5	-3
87	-4	-1	-3	5	3	2	-2	-1	-1
88	1	0	1	0	0	0	-3	-3	0
89	-1	-1	0	1	0	1	-1	0	-1
90	-7	-6	-1	-3	-2	-1	-10	-3	-7
91	-5	-3	-2	-1	0	-1	-3	-1	-2
92	-2	-2	0	2	1	1	1	2	-1
93	2	-1	3	2	1	1	1	0	1
94	1	0	1	.	3	.	-1	-1	0
95	1	0	1	2	0	2	-6	-4	-2
96	-5	-4	-1	-3	-2	-1	-6	-3	-3
97	-6	-3	-3	-4	-2	-2	-3	-2	-1
98	-16	-8	-8	7	-1	8	4	0	4
99	-3	0	-3	-3	0	-3	-3	-2	-1
100	.	-3	.	2	0	2	-4	-3	-1

Male
Trend

Obs	H_o1	1/7	5/11	H_o2	3/9	6/12	H_o3	2/8	4/10
1	0	-2	2	0	0	0	-3	-3	0
2	6	2	4	0	1	-1	-6	-2	-4
3	1	1	0	0	0	0	-1	-1	0
5	-2	-2	0	0	0	0	-3	-3	0
8	4	1	3	-2	0	-2	-2	-1	-1
12	5	0	5	-1	1	-2	-8	-4	-4
13	0	0	0	-3	-1	-2	0	1	-1
14	3	-1	4	0	-3	3	.	.	1
15	3	-1	4	-1	0	-1	-1	-1	0
16	5	0	5	3	1	2	-7	-3	-4
17	3	1	2	0	0	0	-5	-3	-2
19	3	1	2	-2	-1	-1	-7	-3	-4
20	2	1	1	0	0	0	-2	-2	0
21	2	-1	3	-1	0	-1	-1	-2	1
23	-1	-3	2	5	1	4	0	-1	1
24	.	.	0	2	0	2	-3	-3	0
25	0	-1	1	-2	-1	-1	-7	-5	-2
27	4	1	3	0	0	0	-2	-2	0
29	4	0	4	2	1	1	-4	-4	0
31	5	3	2	0	0	0	-6	-3	-3
32	0	-2	2	2	1	1	-2	-1	-1
34	7	5	2	12	6	6	-14	-8	-6
36	-4	-5	1	2	3	-1	-6	-4	-2
37	0	0	0	0	0	0	-4	-2	-2
38	4	1	3	-1	0	-1	1	1	0
39	1	-2	3	1	1	0	-1	-2	1
40	4	-1	5	-2	-3	1	3	4	-1
42	4	-2	6	0	0	0	-2	-2	0
43	0	-1	1	0	1	-1	-2	0	-2
47	3	1	2	2	2	0	-4	-1	-3
49	6	1	5	0	0	0	-2	-2	0
51	2	-1	3	-1	0	-1	-8	-6	-2
52	-2	-2	0	0	0	0	-7	-4	-3
53	-3	-3	0	7	8	-1	8	3	5
54	1	1	0	-1	0	-1	-6	-4	-2
56	0	1	-1	5	7	-2	-3	-3	0
57	0	-1	1	-4	0	-4	-4	-1	-3
59	2	1	1	.	1	.	-3	-3	0
61	5	1	4	.	.	-2	-2	-2	0
62	-1	0	-1	-1	1	-2	-8	-5	-3
63	0	-1	1	1	1	0	1	0	1
65	6	1	5	-3	0	-3	-3	-4	1
66	3	2	1	3	2	1	-1	-2	1
68	3	0	3	-2	0	-2	-5	-2	-3
69	0	0	0	1	1	0	-3	-3	0
70	3	-2	5	4	0	4	0	-1	1
71	3	0	3	1	1	0	-4	-2	-2
72	-3	-3	0	1	0	1	-4	-4	0
73	3	1	2	2	2	0	-4	-1	-3
74	-1	2	-3	1	0	1	2	1	1
76	6	3	3	-2	0	-2	-2	-1	-1
77	2	0	2	2	1	1	1	0	1
78	4	-1	5	4	2	2	.	.	0
79	1	-1	2	-1	-1	0	-6	-3	-3
80	5	1	4	0	0	0	-3	-1	-2
82	6	2	4	2	1	1	-5	-2	-3
84	3	1	2	1	1	0	-6	-4	-2

Male Trend Obs	H_O1	1/7	5/11	H_O2	3/9	6/12	H_O3	2/8	4/10
85	3	0	3	0	-1	1	-2	-3	1
86	3	-1	4	0	1	-1	-3	-2	-1
87	3	1	2	2	2	0	-6	-4	-2
88	-1	-1	0	-1	0	-1	-5	-3	-2
89	3	-1	4	5	2	3	3	1	2
90	-3	-6	3	0	1	-1	-5	-4	-1
92	1	-2	3	1	1	0	-3	-2	-1
94	-3	0	-3	.	.	-5	0	0	0
96	4	0	4	-1	0	-1	-3	-3	0
97	2	1	1	1	2	-1	-3	-1	2

Female Trend Obs	H_O1	1/7	5/11	H_O2	3/9	6/12	H_O3	2/8	4/10
4	8	3	5	6	5	1	-5	-5	0
6	5	2	3	1	3	-2	-8	-7	-1
7	-1	-1	0	.	.	0	0	-2	2
9	1	1	0	0	0	0	-3	-2	-1
10	6	1	5	2	0	2	-7	-4	-3
11	2	-1	3	2	2	0	-3	-2	-1
18	7	2	5	4	2	2	-2	-1	-1
22	3	0	3	1	1	0	-5	-4	-1
26	0	-2	2	-2	1	-3	-9	-7	-2
28	4	-1	5	5	5	0	1	-2	3
30	7	2	5	4	3	1	-1	-3	2
33	1	0	1	1	1	0	-1	-1	0
35	-2	-2	0	3	2	1	-4	-3	-1
41	-1	-6	5	-2	0	-2	-9	-5	-4
44	3	4	-1	2	1	1	0	-1	1
45	-7	-4	-3	-1	-2	1	-3	-1	-2
46	6	3	3	0	0	0	1	0	1
48	0	1	-1	0	0	0	-1	0	-1
55	6	3	3	2	4	-2	.	-2	.
58	8	3	5	-3	-1	-2	-4	0	-4
60	-3	-2	-1	.	.	1	-9	-6	-3
64	-2	2	-4	5	7	-2	1	-5	6
67	1	0	1	-2	0	-2	-3	-3	0
75	7	3	4	13	7	6	5	6	-1
81	5	2	3	-2	0	-2	-7	-4	-3
83	7	2	5	2	2	0	-1	-2	1
91	-6	-4	-2	1	2	-1	-3	-2	-1
93	7	2	5	5	1	4	1	-2	3
95	5	1	4	1	0	1	-4	-3	-1
98	4	0	4	-5	0	-5	-12	-4	-8
99	4	0	4	8	6	2	-4	-5	1
100	-1	-1	0	3	4	-1	-3	-2	-1

Male Preference Obs	H_o1	1/7	5/11	H_o2	3/9	6/12	H_o3	2/8	4/10
1	2	0	2	0	0	0	0	0	0
2	-2	-2	0	2	2	0	-3	-3	0
3	3	0	3	-1	1	-2	-3	-3	0
5	.	.	4	5	5	0	2	1	1
8	3	0	3	-3	-1	-2	-4	-4	0
12	0	0	0	-2	-1	-1	-3	-1	-2
13	-4	-4	0	-2	0	-2	2	2	0
14	5	1	4	0	-1	1	.	.	1
15	1	-3	4	2	2	0	6	-1	7
16	0	0	0	-8	-3	-5	-4	-3	-1
17	.	.	0	-1	0	-1	0	0	0
19	-1	0	-1	1	0	1	-5	-3	-2
20	0	0	0	3	2	1	-1	-1	0
21	0	0	0	-1	0	-1	2	2	0
23	0	0	0	1	0	1	2	1	1
24	.	.	2	3	1	2	-3	-2	-1
25	-1	-1	0	0	0	0	-3	-2	-1
27	1	1	0	0	0	0	-1	-1	0
29	0	0	0	0	0	0	0	4	-4
31	2	2	0	.	.	-1	0	1	-1
32	2	0	2	5	4	1	-3	-1	-2
34	-3	0	-3	-1	0	-1	0	0	0
36	-1	-3	2	6	3	3	-2	-2	0
37	-1	-1	0	0	0	0	0	0	0
38	-3	-1	-2	0	-2	2	-7	-3	-4
39	1	0	1	0	0	0	-2	-2	0
40	5	1	4	0	-4	4	2	5	-3
42	-2	-2	0	0	0	0	-6	-5	-1
43	-5	-4	-1	0	0	0	-3	-1	-2
47	-4	0	-4	0	1	-1	0	1	1
49	2	2	0	4	1	3	-3	-2	-1
51	-3	0	-3	-7	-3	-4	-7	-5	-2
52	0	-1	1	0	0	0	-3	-1	-2
53	.	.	-6	.	.	-8	.	.	-5
54	0	-2	2	1	3	-2	-7	-4	-3
56	-4	-1	-3	-2	-2	0	-5	-3	-2
57	-4	-2	-2	-2	1	-3	-2	0	-2
59	-11	-6	-5	.	-1	.	-8	-5	-3
61	3	1	2	.	.	5	-1	0	-1
62	-6	-2	-4	-3	-2	-1	-8	-5	-3
63	1	1	0	4	3	1	4	1	3
65	-2	-1	-1	-4	-3	-1	1	-2	3
66	-6	-3	-3	0	1	-1	-4	-4	0
68	-2	-1	-1	2	1	1	-4	-2	-2
69	-3	-3	0	-3	-1	-2	-3	-2	-1
70	2.5	2.5	0	-3	-3	0	-2	-2	0
71	1	0	1	4	3	1	-2	0	-2
72	-2	-2	0	11	6	5	-1	-2	1
73	-2	0	-2	-1	0	-1	-1	-1	0
74	-6	-3	-3	-1	-1	0	3	0	3
76	4	1	3	-4	0	-4	-3	-2	-1
77	-2	-1	-1	3	1	2	-2	-1	-1
78	-8	-3	-5	3	3	0	.	.	-3
79	-3	-2	-1	2	0	2	-7	-3	-4
80	-2	-2	0	0	1	-1	-2	-2	0
82	2	-1	3	-5	-4	-1	-10	-5	-5
84	-3	-1	-2	-2	1	-3	-4	-3	-1

Male Preference Obs	H_o1	1/7	5/11	H_o2	3/9	6/12	H_o3	2/8	4/10
85	-2	-3	1	-4	-1	-3	-7	-3	-4
86	-1	-4	3	6	4	2	-8	-5	-3
87	-4	-1	-3	5	2	3	-2	-1	-1
88	1	0	1	0	0	0	-3	-3	0
89	-1	-1	0	1	1	0	-1	0	-1
90	-7	-6	-1	-3	-1	-2	-10	-3	-7
92	-2	-2	0	2	1	1	1	2	-1
94	1	0	1	.	.	3	-1	-1	0
96	-5	-4	-1	-3	-1	-2	-6	-3	-3
97	-6	-3	-3	-4	-2	-2	-3	-2	-1

Female Preference Obs	H_o1	1/7	5/11	H_o2	3/9	6/12	H_o3	2/8	4/10
4	0	0	0	14	8	6	.	0	.
6	1	0	1	-2	-1	-1	-1	-1	0
7	-2	-1	-1	.	.	.	.	-4	.
9	0	0	0	1	1	0	1	1	0
10	1	1	0	1	0	1	-4	-1	-3
11	-1	-1	0	0	0	0	0	0	0
18	1	-2	3	1	0	1	0	0	0
22	-1	0	-1	-2	2	-4	-1	-1	0
26	0	1	-1	-2	-3	1	-2	-1	-1
28	-1	0	-1	5	4	1	2	-1	3
30	-3	0	-3	0	1	-1	-1	-3	2
33	2	1	1	1	1	0	-1	-1	0
35	0	0	0	0	0	0	-1	-1	0
41	2	1	1	0	0	0	-3	-2	-1
44	2	1	1	-5	-4	-1	3	-2	5
45	2	2	0	1	1	0	4	2	2
46	-2	-2	0	-4	-3	-1	.	.	-1
48	0	1	-1	2	1	1	-1	0	-1
55	-2	-1	-1	-1	1	-2	.	2	.
58	-8	-3	-5	-7	-2	-5	-7	-4	-3
60	-4	-3	-1	.	.	0	.	.	-3
64	-4	0	-4	5	5	0	-4	-3	-1
67	-1	0	-1	-2	0	-2	-3	-3	0
75	2	0	2	0	0	0	0	0	0
81	-5	-3	-2	-2	0	-2	-7	-4	-3
83	3	3	0	5	1	4	1	0	1
91	-5	-3	-2	-1	-1	0	-3	-1	-2
93	2	-1	3	2	1	1	1	0	1
95	1	0	1	2	2	0	-6	-4	-2
98	-16	-8	-8	7	8	-1	4	0	4
99	-3	0	-3	-3	-3	0	-3	-2	-1
100	.	-3	.	2	2	0	-4	-3	-1

Appendix F. Demographic Information

		Control	Experimental	Total
1.	**Sex**			
	Male	31	36	67
	Female	18	14	32
2.	**Age**			
	Under 18	0	0	0
	18-25	3	4	7
	26-35	27	25	52
	36-45	12	15	27
	46-55	4	3	7
	56-65	3	3	6
	Over 65	0	0	0
3.	**Highest Education Level**			
	High School	0	0	0
	Some College	0	5	5
	Associate Degree	2	2	4
	Baccalaureate Degree	13	12	25
	Some Graduate Courses	14	16	30
	Masters Degree	17	15	32
	Doctorate Degree	2	0	2
4.	**Rank/Grade**			
	E1-E4	0	0	0
	E5-E7	0	3	3
	E8-E9	0	1	1
	O1-O3	21	20	41
	O4-O5	6	5	11
	O6	0	0	0
	O7 and above	0	0	0
	GS1-GS8	0	0	0
	GS9-GS12	12	11	23
	GS13-GS15+	5	3	8
	GM13-GM15+	3	5	8
	SES	0	0	0
	Not applicable	1	2	3
	No response	1	0	1
5.	**Years of Service**			
	0-5	11	16	27
	6-10	17	10	27
	11-15	9	5	14
	16-20	4	10	14
	21-25	4	4	8
	26-30	1	1	2
	Over 30	3	3	6
	Not applicable	0	1	1
6.	**Supervisory Level**			
	Supervise no one	27	31	58
	1st level	15	11	26
	2nd level	3	4	7
	3rd level	4	1	5
	4th or above	0	3	3

	Control	Experimental	Total
7. See icon/picture graphs			
Never	1	2	3
Once a year	1	3	4
Once a month	1	3	4
Twice a month	4	4	8
Once a week	16	18	34
Every other day	10	7	17
Every day	16	13	29
8. Use graphs in decision-making			
Never	5	6	11
Once a year	3	4	7
Once a month	13	17	30
Twice a month	10	8	18
Once a week	11	10	21
Every other day	2	0	2
Every day	5	5	10
9. Construct graphs			
Never	1	8	9
Once a year	8	9	17
Once a month	16	20	36
Twice a month	13	4	17
Once a week	7	8	15
Every other day	3	0	3
Every day	1	1	2
10. Graphic method preferred			
Horizontal bar	8	12	20
Vertical bar	30	29	59
Horizontal icon bar	2	1	3
Size manipulated icon	4	4	8
Vertical icon bar	4	4	8
No response	1	0	1
11. Uneasy about graphs			
No	32	34	66
Yes	17	16	33
Car Exports	6	3	9
Literacy Rate	3	3	6
Work Related Injuries	2	4	6
Teen Liquor Consumption	3	2	5
Leisure Time	3	1	4
Bomber Payload	2	2	4
Tools Made in the US	1	3	4
H.S. Graduates in Army	1	2	3
Number of Homeowners	1	2	3
Savings	0	2	2
Horizontal bars	0	2	2
All icons	0	1	1
Wheat Exports	0	1	1
Car Sales	0	1	1
Small ink ratio	0	1	1
12. Ambiguous Graphs			
No	20	25	45
Yes	29	25	54
Car Exports	20	13	33
Leisure Time	5	8	13
Tools Made in the US	1	5	6
Savings	2	4	6
Car Sales	2	4	6

	Control	Experimental	Total
12 continued			
Literacy Rate	3	2	5
H.S. Graduates in Army	2	2	4
Bomber Payload	1	2	3
Number of Homeowners	1	2	3
All icons	1	1	2
Teen Liquor	1	1	2
Wheat Export	1	0	1
Work Related Injuries	0	1	1
Complicated icons	0	1	1
Horizontal bars	0	1	1
Vertical icons	0	1	1
Vertical bars	0	1	1
13. Previous knowledge of experiment			
No	47	49	96
Yes	2	1	3

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13. ABSTRACT *(Maximum 200 words)*
This thesis investigated whether individuals interpreted iconic graphs differently than traditional graphs. A literature review revealed a lack of current research concerning iconic graphs. Using guidelines previously created for high-integrity graphics, a timed, pretest-posttest experiment was developed to compare the impressions rendered by both traditional and iconic graphs to determine whether men and women interpret the two types of graphs in the same way. It was also used to determine whether traditional bar graphs or iconic graphs were preferred by the subjects. Ninety-nine subjects, all employees of the Royal Australian Air Force, United States Air Force, or defense contractors, were involved in the experiment. Through the use of the Mann-Whitney U Test, it was determined that the method of presentation did not affect an individual's interpretation of the graph. Individuals did, however, prefer the traditional methods of presentation. It was also determined that gender did not have an affect on an individual's ability to interpret a graph.

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